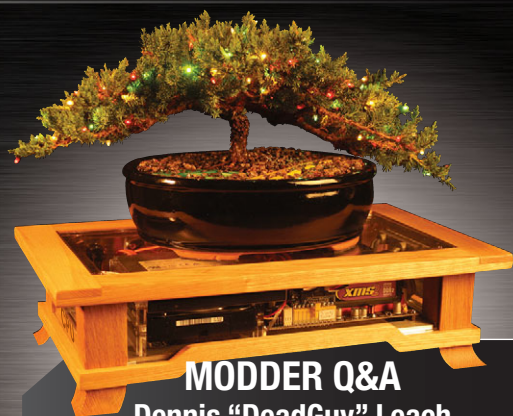


NVIDIA GeForce GTX 1080 Ti | AMD Ryzen 7 1800X | Z270 Motherboard Roundup

# cpu

COMPUTER POWER USER



MODDER Q&A  
Dennis "DeadGuy" Leach



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## Corsair Launches First RGB DDR4 Memory Under Vengeance Brand

Corsair launched an RGB version of its Vengeance DDR4 memory. The new line is the first memory from the company to include RGB lighting. The new Vengeance RGB DDR4 has four lighting modes: static, breathing, rainbow, and color shift. Builders can use Corsair LINK software to customize the lighting to match their builds or provide additional information, such as having colors reflect system temperature ranges. Corsair says the memory modules use high-quality components such as hand-screened ICs and customized PCBs that provide superior performance when overclocking. The heat spreaders on the modules also are designed to provide greater stability under load. The new RGB memory is available immediately in kits of 16GB (2 x 8GB) and 32GB (4 x 8GB); both kits have a frequency of 3,000MHz. The company says additional capacities and frequencies will be added soon.

## NZXT Introduces New Aer F Fans

NZXT announced its new Aer F, a case fan that features removable trim pieces that buyers can purchase separately. The Aer F fans are available in two sizes: 120mm and 140mm. They have fluid dynamic bearings that are meant to last for at least 60,000 hours, or six years of operation. The PWM fans have sleeved cables, and NZXT says the blades were designed to improve airflow and reduce noise. The fans are basic black, but the circular trim pieces snap in place around the frame that surrounds the blades. These pieces let users add a touch of red, white, or blue to the fans to match the decor of their builds. The trim pieces come in pairs at both fan sizes for \$5.99/pair. MSRP for the new Aer F fans is \$17.99 for 120mm and \$19.99 for 140mm. Twin packs of fans offer the ability to buy multiple fans at a discount. The 120mm twin pack is \$29.99 while the 140mm twin pack is just \$32.99.



### WATCHING THE CHIPS FALL

Here is the pricing information for various AMD and Intel CPUs.

CPU	Released	Original Price	Last Month's Price	Online Retail Price*
AMD Ryzen 7 1800X	3/2/2017	\$499	\$499.99	\$499.99
AMD Ryzen 7 1700X	3/2/2017	\$399	\$399.99	\$399.99
AMD Ryzen 7 1700	3/2/2017	\$329	\$329.99	\$299.99
AMD FX-9590 Eight-Core (Vishera)	6/11/2013	n/a	\$189.99	\$178.00
AMD FX-8370 (Vishera)	9/2/2014	\$199.99	\$189.99	\$149.99
AMD A10-7890K (Godavari)	3/1/2016	\$164.99	\$148.99	\$148.99
AMD A10-7870K (Godavari)	5/28/2015	\$137	\$124.99	\$119.99
AMD A10-7860K (Godavari)	2/2/2016	\$116.99	\$109.99	\$94.99
AMD Athlon X4 880K (Godavari)	3/1/2016	\$94.99	\$91.86	\$79.99
AMD Athlon X4 845 (Carrizo)	2/2/2016	\$69.99	\$67.99	\$56.60
Intel Core i7- 6950X (Broadwell E)	5/31/2016	\$1,723**	\$1,644.99	\$1,649.99
Intel Core i7- 5960X Eight-Core (Haswell)	8/29/2014	\$999**	\$1,095.74	\$1,069.65
Intel Core i7- 6900K (Broadwell E)	5/31/2016	\$1,089**	\$1,049.99	\$1,049.99
Intel Core i7- 6850K (Broadwell E)	5/31/2016	\$617**	\$609.99	\$574.99
Intel Core i7- 5930K Six-Core (Haswell)	8/29/2014	\$583**	\$619.29	\$620.80
Intel Core i7-5820K Six-Core (Haswell)	8/29/2014	\$389**	\$409.26	\$389.99
Intel Core i7-6700K Quad-Core (Skylake)	8/5/2015	\$359**	\$339.99	\$339.99
Intel Core i7-4790K Quad-Core (D.Canyon)	6/25/2014	\$339**	\$408.78	\$406.99
Intel Core i7-4790 Quad-Core (Haswell)	5/11/2014	\$303**	\$333.00	\$372.16
Intel Core i5-6600K Quad-Core (Skylake)	8/5/2015	\$249**	\$239.99	\$239.99

\* As of March

\*\* Manufacturer's estimated price per 1,000





## EKWB Now Gives You Pivoting Ports

EK Water Blocks has released an ingenious GPU terminal with dual ports that swivel a full 360 degrees, so you can install your liquid-cooling pipes from any angle. The EK-FC Terminal Rotary 90 has standard G1/4" port fittings that sit at 90 degrees to the block, which may be preferred or even required depending on certain build configurations. But arranging for piping to fit a typical 90-degree port can limit your cooling options, as the piping has to be set in one direction. EKWB's new terminal is much more accommodating, as the ports can swivel a full 360 degrees. This means your inflow and outflow piping can come from any direction. The new terminal is made of PTFE-coated forged brass, and the black finish will work with the color scheme in any build. The part can be swapped out for the stock terminal in any current EK full-cover GPU waterblock (EKWB notes on its website that the terminal is not compatible with original CSQ design full-cover blocks). The MSRP for the new EK-FC Terminal Rotary 90 is \$24.95.

## Logitech Introduces New G Pro Mechanical Gaming Keyboard

Logitech announced a new mechanical gaming keyboard. The company says it developed the G Pro Mechanical Gaming Keyboard for professional-level gaming competitions, and that its design team worked with pro eSports gamers to create the new plank. The G Pro is a small keyboard with a tenkeyless design, and it uses Logitech's proprietary Romer-G mechanical switches. The Romer-G switches register key presses at 1.5mm, which the company says is up to 25% faster than other mechanical switches. The compact plank has a steel backplate that adds durability. Pro gamers travel with their keyboards from tournament to tournament, so the G Pro comes with a detachable micro-USB cable. The keyboard has RGB lighting and onboard memory for saving personalized settings. Logitech says the new G Pro will be available at retail soon with an MSRP of \$129.99.



## X2 Products Adds White Version To Its Empire Gaming Case Line

Netherlands-based X2 Products has introduced a white version of its Empire gaming chassis. The steel ATX case has a trapezoid shape with a distinctive angular sloping front that sports a red X2 logo. The case comes with two RGB LED fans and features large acrylic side windows.

The Empire has plenty of room inside. It can handle graphics cards up to 400mm long and as many as seven 120mm fans. There's also room for a radiator up to 360mm for folks who prefer liquid-cooling setups. The case has seven expansion slots and three internal 3.5-inch drive bays.

X2 Products says the white version of the X2 Empire carries an MSRP of \$99.99.



## BIOSTAR Announces M200 Series SSDs For Compact M.2 Form Factor

BIOSTAR has launched a new line of SSDs that use the M.2 2280 form factor. The company calls the compact SSD line the M200 Series. Drives in the M200 Series are extremely small and draw a minimal amount of power, so they are being targeted at users with notebooks, HTPCs, and other small-form-factor systems. The drives feature a Marvell controller and BGA memory and transfer data at SATA3 6Gbps speeds.

BIOSTAR says the M200 Series will be available in two capacities, 120GB and 240GB. Maximum read speed for both capacities is 530MBps. Maximum write speed for the 120GB drive is 380MBps, while the 240GB drive reaches write speeds of 410MBps. Both models of the drive support Windows, Linux, and Mac operating systems.

### HARDWARE MOLE



## ASUS Launches ROG Strix GD30

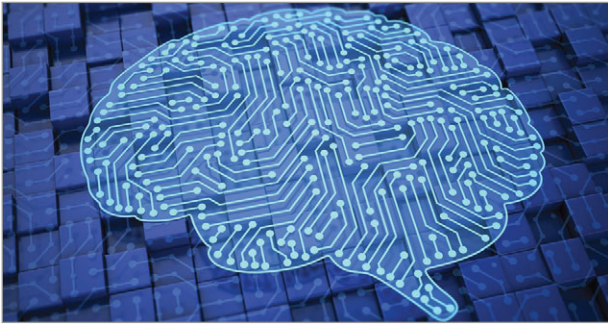
The Republic Of Gamers now has a Strix-branded desktop. The ROG Strix GD30 is a barebones system that can be customized with components that match a user's budget. The system also can be customized on the outside, as the case has multiple pieces in a black-and-white color scheme that can be arranged to present up to half a dozen different chassis configurations. The front and top panels can be combined in a way that brings to mind a storm trooper from Star Wars, and ROG is quick to point out that the GD30 makes a great system for fans of the movie. There's a windowed side panel for viewing components, but instead of a solid-glass side, the GD30 window has a "honeycomb" metal pattern that includes the ASUS logo. ROG says the panel reduces electromagnetic interference. The system comes with Windows 10 and ASUS AEGIS III software.

## MSI Introduces The Z270 MPOWER GAMING TITANIUM

MSI announced the Z270 MPOWER GAMING TITANIUM, an imposing looking motherboard that bristles with metal armor and heatsinks. On the back, the socket 1151 board has a gigantic "titanium" backplate to help support the big graphics cards and coolers. The motherboard is loaded with the latest hi-tech goodies and can handle up to 64GB of DDR4-4000. It supports Intel Optane and has three Turbo M.2 slots with Shield thermal protection. The TITANIUM supports NVIDIA SLI as well as AMD CrossFire, and it comes with Killer GAMING LAN for low latency while gaming online. The motherboard also lets you control your entire system's lighting using MSI's Mystic Light Sync software.







## Research Could Lead To Better Artificial Intelligence Systems

A new computational model being developed at Northwestern University could overcome one obstacle to artificial intelligence—being able to see and understand the world as humans do. Human intelligence is characterized by the ability to solve complex visual problems, the Northwestern University researchers note, so developing artificial intelligence systems that can do that could shrink the gap between computer and human cognition. The system was developed by Ken Forbus, a Northwestern University professor, and Andrew Lovett, a former postdoctoral researcher at the university. It's based on an AI platform called CogSketch, which can solve visual problems and understand sketches to give immediate, interactive feedback. The researchers tested their system against Raven's Progressive Matrices. "The model performs in the 75th percentile for American adults, making it better than average," Forbus said. "The problems that are hard for people are also hard for the model."

## Software Vulnerabilities Up, Patch Rates Down, Study Shows

Although the number of software vulnerabilities reached record levels last year—17,147 vulnerabilities in 2,136 products from 246 vendors—patch rates were down, according to the newest annual report from Secunia Research at Flexera Software. The 50 most popular products recorded 1,626 vulnerabilities, a 15% increase in the five-year trend. Despite those figures, the survey did have some good news: among the top 50 products, 81% of all vulnerabilities and 92.5% of applications impacted by vulnerabilities had patches available on the day the problems were disclosed. The number of zero-day exploits (22) was also down compared to 2015. Microsoft applications account for more than 70% of the 50 most popular applications on private PCs but only 22.5% of vulnerabilities (9% of those were in Windows 7). Web browsers were among some of the most-exploited programs, with the five most popular browsers accounting for 713 vulnerabilities, up 27.5% from 2015.

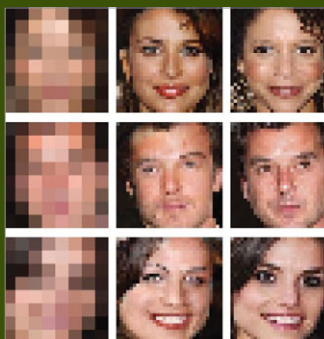


### SOFTWARE SHORTS

## Google Software Can Fill In Missing Pixels In Photos

Researchers at Google Brain are working on a tool that can fill in the missing pieces—or at least reasonable facsimiles of them—in low-resolution or grainy images. The research could bring about dramatic improvements in areas such as investigative work, where high-resolution photos of criminals aren't always available but could make the difference in whether a case gets solved.

The tool works based on a system of prior knowledge. In testing the system, for example, the researchers used low-resolution images of faces. The software used a conditioning network to map the low-resolution photo



against high-resolution images trying to make a match, while a prior network adds realistic high-resolution details to make the output more realistic, the researchers explain. The result wasn't an exact image, because the system uses "hallucinating" techniques to create the final image's sharp details, but the images on average look photo-realistic, according to the researchers. (The image at left shows the test photo in the first column, the system-created image in the second column, and the "ground truth" image in the third).

Researchers presented study participants with a series of two images (the true image and the new system's "corresponding prediction") and they were asked to say which image was from a camera. Test participants were fooled about 10% of the time (a 50% score would have shown the system perfectly confused subjects).



## Always-Online, Connected Lifestyles Impact Families, Study Shows

Kids are spending more time on digital devices. Although that finding, part of the 2017 Connected Family Survey conducted by Intel Security, isn't anything new, what might surprise some is the impact our digital, always-online lifestyles are having on families. The introduction of smartphones and tablets has brought about a change in bedtime habits. More than 75% of parents let their children bring an internet-connected device to bed, and 32% of parents have argued with their child about bringing a device to bed. Many parents monitor how much time children spend in front of a screen, with 20% allowing three to four hours a day and 48% allowing one to two hours. All that screen time comes with concerns. About 80% of adults are worried their children could interact with a cyber predator or criminal online, and 34% have discovered their child visited an inappropriate website. But it's not just kids guilty of using devices when they shouldn't: About 36% of parents said their child has called them out for being on their device during family time.

## Poll: Most Americans Not Concerned About Online Tax-Related ID Theft

Despite reports of tax-related identity theft reaching monumental numbers last year—787,000 confirmed reports totaling more than \$4.4 billion—most Americans aren't worried about tax fraud, according to a survey by CyberScout. In fact, 58% of Americans aren't worried about tax fraud at all.

CyberScout surveyed 1,500 United States consumers and found that most Americans are also fairly lax about the security of their tax forms. Just 35% of taxpayers demand their tax preparers use two-factor authentication, the survey notes. Only 18% use an encrypted USB drive to save important tax documents and worksheets, and 38% store those documents on a computer hard drive or in the cloud, which CyberScout points out are susceptible to a variety of attacks. The 57% of Americans who are late tax filers (those who wait until March, April, or later) are more susceptible to tax fraud because fraudsters have additional time to impersonate them, according to CyberScout.

In addition to filing early, the company recommends taxpayers use long and strong passwords, use direct deposit or a locking mailbox if you're receiving a refund, and monitor and protect your accounts and personal identity online and in social media.



### SITE SEEING

## New Technique Identifies Users Across Browsers

It's a well-known fact that what we do online can be tracked by any number of sites, often with good intentions of improving customer service or, in the case of banking or financial institutions, keeping us more secure. Fingerprinting is one of the most common techniques. It works regardless of whether you have cookies enabled, but existing methods are typically limited to a single user and one browser. A technique being developed by a team of researchers at Lehigh University and Washington University in St. Louis, though, is considered the first cross-browser fingerprinting to use OS- and hardware-level features. The researchers

note that the new technique can be used as part of stronger multifactor user authentication even across browsers or to help improve existing privacy-preserving works.

Their proposed technique will look at OS- and hardware-level features such as those from graphics cards, CPUs, the audio stack, and installed writing scripts, the researchers note. To test the technique, the researchers enlisted the help of users from two crowdsourcing websites who were asked to visit a website using two different browsers of their choosing. The researchers collected data from more than 1,900 users and were able to correctly identify 83.24% of users, which is a more than 14% improvement compared to previous cross-browser fingerprinting techniques.







## Job Of The Month

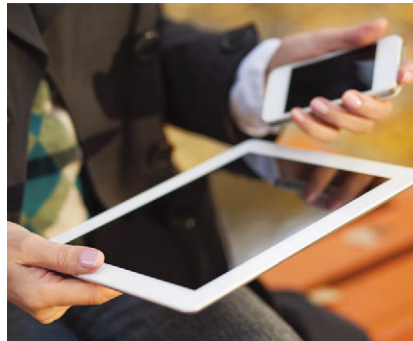
The reports are all over the news: Robots will soon be coming to take our jobs, and millions of positions are at risk. Well, as they say, if you can't beat 'em, join 'em. Boston Dynamics is known for making some of the most technologically impressive (and terrifying looking) robots that exist, including running "dog" robots and humanoid robots that go walking in the woods (just do a quick search online for the videos). The company has an opening for a software perception engineer to "give our robots the ability to navigate through forests and across mountains." Applicants must be wise in the ways of robotics algorithms and data structures and be experienced Linux users who can write up a coding storm with C++. It also helps to know some Python and be comfortable debugging hardware. This position is at the company's offices in Waltham, Massachusetts. One more note: If you do land a spot with the company, please remember to build a secretive off button into our new robot overlords.

Source: [www.bostondynamics.com](http://www.bostondynamics.com)

## Mobile Warriors Shoppers: Millennials vs. GenX

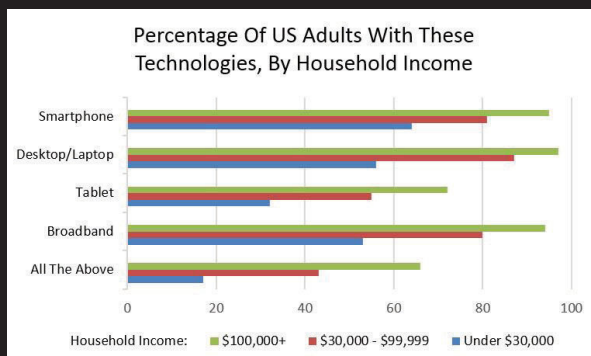
Generation X is the name for the generation following the Boomers. GenXers are now about 36 to 50 years old. Millennials are the generation born toward the end of the 20th Century; they are now between 18 and 35 years old. The research firm Newzoo examined how the two groups compare when it comes to online shopping and making payments at retail. Overall, millennials shop more online. Newzoo says 37% of millennials spend three or more hours shopping online each week, compared with 27% of Generation X. When mobile digital payment technology is available at retailers, 50% of millennials would prefer to use it to pay for their purchases, while only 41% of GenX shoppers would choose that option over more mainstream payment methods such as credit/debit cards or bank transfers.

Source: [Newzoo](http://Newzoo)



## The Digital Divide, AKA Show Me The Money

A study by Pew Research shows that . . . surprise! . . . households with more money tend to have greater access to new technologies and technology products. The study asked people what types of digital devices (smartphones, desktops/laptops, tablets) they owned and whether they had broadband access at home, and then it broke down the results by household income. As you might imagine, in every category of product/technology, there was a clear correlation between HHI (household income) and access. While two-thirds of people with HHI above \$100K had access to all the technologies mentioned, only 17% of people with HHI lower than \$30K could make that claim.



Source: [Pew Research](http://Pew Research)

## RAW Numbers:

39

The percentage of people in the United States who use their smartphones to access the internet at home. About 88.5% of Americans overall now use the internet.

[ReportLinker.com](http://ReportLinker.com)

50

The percentage of people worldwide who are forecast to use a 4G communications network (aka LTE) by the year 2022. About 67% of all mobile traffic uses LTE today, and that percentage is expected to rise to 82% in five years. Older 2G and 3G networks will continue declining over the next five years, while new 5G networks will carry some 13% of data traffic by 2022.

[ABI Research](http://ABI Research)

4,220

The number of terabytes of data that owners of Chevrolet cars consumed while on the road in 2016. All new Chevy models now come with a 4G LTE connection as standard equipment.

[General Motors](http://General Motors)

114,000

The number of years it would take you to watch all the video downloaded and viewed from YouTube every 24 hours. The website says people now watch more than 1 billion hours of video on YouTube every day. On a separate but related note, YouTube says more than 65 years' worth of new video content is now uploaded to the service daily.

[YouTube](http://YouTube)

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# Now Boarding For Kaby Lake

## We Review Four Z270 Motherboards

AMD's Ryzen processors and new chipsets might have taken some of the luster off of Intel's Kaby Lake CPUs and the Z270 chipset, but there are still plenty of reasons to go Team Blue with your next build. High-speed storage enthusiasts, for example, can build a RAID array with multiple PCIe, NVMe SSDs—each running over a PCIe 3.0 x4 bus. By comparison, Ryzen and the X370 chipset only provide one PCIe 3.0 x4 bus. Motherboard makers also support much faster DDR4 modules with Intel's Z270 chipset (typically up to 4,000MHz) than AMD's X370 chipset, which often top out at 3,200MHz.

Another good reason to consider the Z270 chipset is the platform's relative maturity. Unlike the limited selection of Ryzen motherboards on the market—with most manufacturers only offering three or four boards—most all motherboard companies provide a complete lineup of Z270 motherboards. Many high-end Z270 motherboards with the latest amenities retail for around \$300 and go up to \$500, while more basic boards start around \$125. In short, there's a Z270 board for most any budget.

If you're trying to decide between Z270 and the older Z170 platform, you should consider a few factors, including internal and external device connectivity. Intel provides 24 PCIe 3.0 chipset lanes on Z270, up from 20 PCIe 3.0 lanes on Z170. The extra lanes give motherboard manufacturers quite a bit of flexibility for M.2, U.2, USB, and Thunderbolt



3 connectivity. Almost all of the Z270 motherboards we've tested to date feature two or more USB 3.1 ports, and manufacturers usually include one reversible Type-C port. Many high-end motherboards, such as the models in this roundup, feature multiple M.2 and U.2 ports.

Also, the Z270 chipset has a potential ace up its sleeve in the form of native support for Intel Optane, which is a new storage and memory technology based on 3D XPoint memory media. Intel recently launched its first Optane SSD, the DC P4800X, an enterprise add-in card SSD. When available for consumers, Intel Optane devices are expected function as both high-speed storage and custom virtual memory. Intel Optane performance is likely to be slower than conventional DRAM, but faster than traditional SSDs. In particular, Intel Optane should be good for random workloads at low queue depths, where the majority of real-world activity occurs.

The Z270 chipset supports both Intel's Kaby Lake desktop CPUs, such as the Core i7-7770K, and Skylake processors, such as the Core i7-6700K. With Kaby Lake, Intel provides the usual selection of Core i7/i5/i3 chips, headlined by the unlocked Core i7-7700K and Core i5-7600K. Our test bed features the Core i7-7700K. This quad-core processor boasts Hyper-Threading to handle eight concurrent threads—identical to the Core i7-6700K. The Core i7-7700K is faster than its Skylake counterpart with a 4.2GHz core clock, up 200MHz from the Core i7-6700K, and a 4.5GHz Turbo Boost 2.0 frequency.

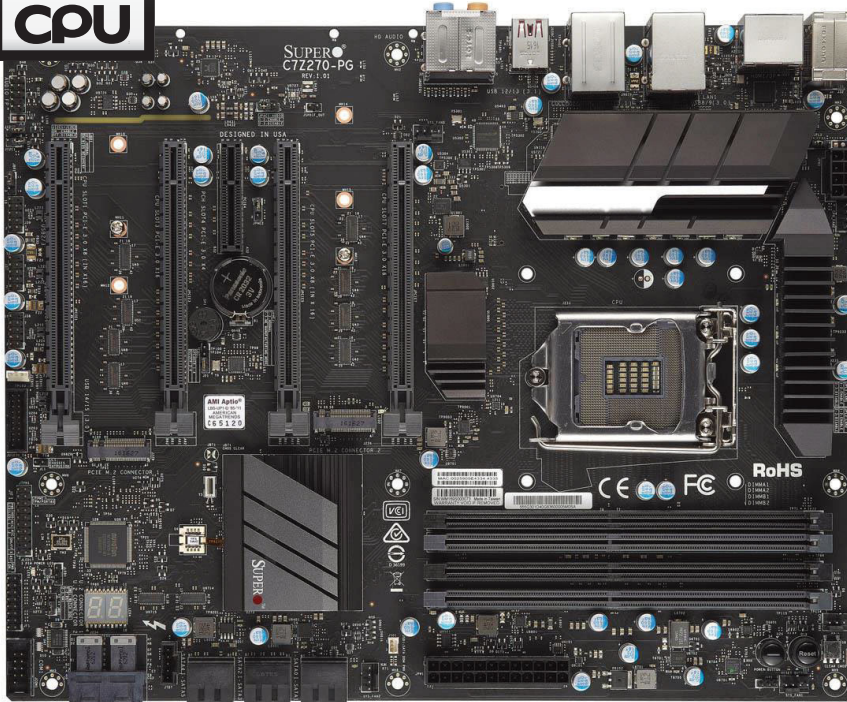
Our test system also features GIGABYTE's GeForce GTX 1080 Xtreme Gaming, 32GB of Corsair Vengeance LED DDR4-3200MHz memory, and a 480GB Patriot Hellfire SSD. To prevent the CPU from throttling under load, we used Alphacool's Eiswand 360 CPU, a huge external AIO liquid cooling tower. The whole system is powered by an EVGA SuperNOVA 850 T2, an 80 PLUS Titanium-certified PSU.

As we mentioned, this roundup features premium Z270 motherboards with high-end models from AORUS, EVGA, MSI, and Supermicro. There's a little something for everyone, whether you're looking for a platform for overclocking, multi-GPU gaming, or luxurious looks.

### Supermicro C7Z270-PG

Since the introduction of Intel's Ivy Bridge processor family and the Z77 chipset, mainstream Intel processors



**C7Z270-PG**\$339 | Supermicro | [www.supermicro.com](http://www.supermicro.com)**HEAVY GEAR**  
**4.0 OUT OF 5**  
**CPU**

**Specs:** Max memory: 64GB DDR4 (DDR4-2400; Max OC: DDR4-3733); Slots: 4 PCIe 3.0 x16, 1 PCIe x4; Storage: 2 M.2 (type 2260/2280/22110), 2 U.2, 6 6Gbps SATA; Rear I/O: 1 HDMI, 1 DisplayPort, 4 USB 3.1 (3 Type-A, 1 Type-C), 2 USB 3.0, 2 USB 2.0, 1 PS/2, 2 Ethernet, 1 S/PDIF, audio I/O; Form factor: ATX; Warranty: 3 years

have come with an integrated graphics controller that provides 16 PCIe 3.0 lanes. With a single GPU and most 2-way SLI or CrossFire configurations, 16 lanes is enough bandwidth to do the job. Things look less rosy with a 3-way or 4-way GPU setup—unless the motherboard, like Supermicro's C7Z270-PG, boasts Broadcom's PEX8747 chip that ups the PCIe graphics lane count to 32. With the extra lanes, the C7Z270-PG runs 2-way setups at x16/x16, 3-way at x8/x8/x8, and 4-way configs at x8/x8/x8/x8.

Extreme graphics are just the start of what you can accomplish with the C7Z270-PG. You can build an incredibly fast RAID 0 configuration

with PCIe SSDs using either the two M.2 slots (both offer support for type 2260/2280/22110 devices) or the two U.2 ports. You could also create a RAID 1 configuration for data mirroring. If you plan to mix and match M.2 and U.2 storage, keep in mind that the top U.2 port will be disabled if you plug an M.2 device into the bottom M.2 slot. For conventional SATA storage, there are six 6Gbps SATA ports that support RAID 0, 1, 5, and 10.

Keeping with the multiplex theme, the C7Z270-PG comes with two Ethernet ports powered by Intel i219V and i210AT NICs. The two LAN ports can work together via teaming to deliver bandwidth up to

2Gbps, or you can connect to two private networks at one time. The dual Ethernet ports are located on the rear panel next to four USB 3.1 ports (one Type-C and 3 Type-A) and two USB 3.0 ports. Needless to say, the rear I/O connectivity has a power user flavor.

Like all Supermicro motherboards we've seen, the C7Z270-PG features the company's "server DNA" with materials qualified by Supermicro's server standards. Of note, Supermicro motherboards are validated with full-load server testing methods, which include pushing the board at 100% load for 150 hours. Despite the excellent power-handling hardware, the C7Z270-PG doesn't have as many overclocking conveniences the other boards in our roundup. The basics are covered—with a debug LED and onboard power, reset, and clear CMOS buttons—but there are no voltage read points or a BIOS switch, for instance.

Supermicro updated the BIOS interface from its Z170 motherboards, and while it looks better, there's a lot of scrolling involved to reach the overclocking settings. Once you've located the OC options, the process is fairly intuitive, but it'd be nice if the key adjustments, such as the clock ratio multiplier, were near the top of the settings.

In the past, Supermicro's motherboards haven't always matched up well with the competition in the onboard audio department. The C7Z270-PG boasts the upgrades gamers demand with Japanese ELNA audio capacitors and a TI OPA1612 operational amplifier that can output hi-fidelity sound. Supermicro also adds shielding to the audio path to protect from noise and distortion.

With the four PCIe x16 slots and two M.2 slots, the expansion portion of the PCB is fairly tight. The location of the bottom PCIe x16 slot—just above the USB headers on the bottom of board—means any GPU in the bottom slot will need to be a single slot card, unless you

have extra space below the expansion slots in your case. A red LED runs along the audio section of the PCB, but otherwise, there's almost no other LED illumination on the board. We'd have preferred to have some way to shut off the red LED, as this option is commonly available on other boards we've reviewed. Some builders might not want any LED light, while the red color may clash with your build's color scheme.

Our test system configuration didn't take advantage of the motherboard's exceptional 3-way and 4-way SLI and CrossFire support, but that didn't stop the board from posting the best overall frame rates in our game tests. The frame rates were only a frame or two higher than the competition, but the C7Z270-PG did produce the best, or tie for the best, with 107fps in Metro: Last Light, 119fps in Dying Light, and 86fps in Witcher 3. On the whole, other benchmarks results were solid.

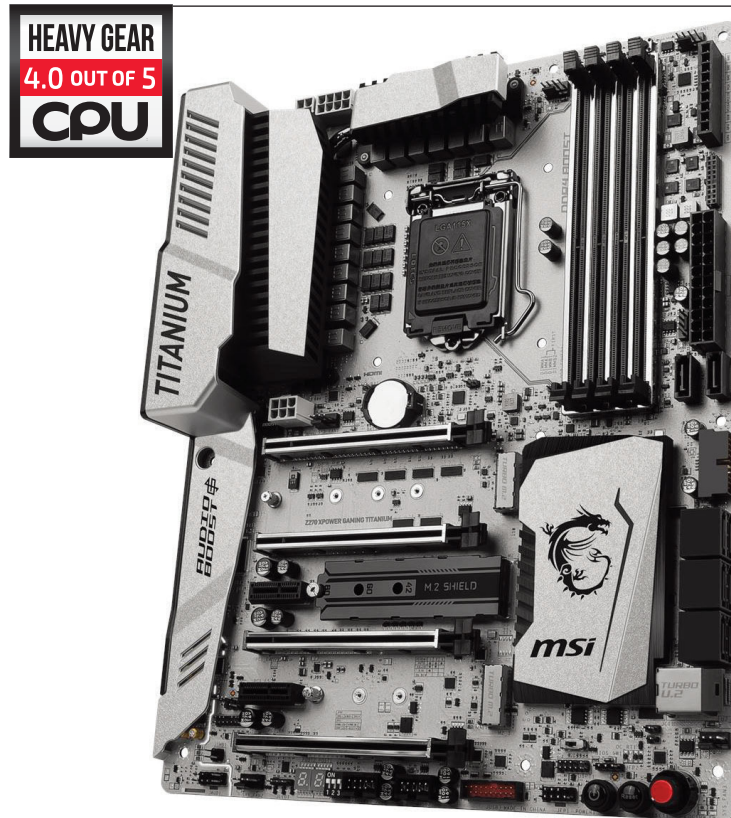
Motherboards with the Broadcom PEX8747 chip typically don't come cheap—with some retailing for \$500. Supermicro manages to include the multi-GPU support with an MSRP of \$339, an impressive feat. A few more overclocking conveniences, both onboard and in the BIOS, would have been nice, but solid, speedy connectivity for PCIe SSDs and NIC teaming still make this a very intriguing option for performance enthusiasts.

### MSI Z270 XPOWER GAMING TITANIUM

MSI designs much of its motherboard lineup to suit gamers with high-end enhancements that improve onboard audio and networking, as well as peripheral connectivity. The Z270 XPOWER GAMING TITANIUM comes with MSI's best gaming additions, plus a wide array of tools to optimize overclocks, as well as storage and GPU performance. If you're contemplating an extreme configuration, whether it's a 1GHz

#### Z270 XPOWER GAMING TITANIUM

\$329.99 | MSI | [us.msi.com](http://us.msi.com)



**Specs:** Max memory: 64GB DDR4 (DDR4-2400; Max OC: DDR4-4000); Slots: 4 PCIe 3.0 x16, 2 PCIe x1; Storage: 3 M.2 (1 type 2242/2260/2280/22110, 2 type 2242/2260/2280), 1 U.2, 6 6Gbps SATA; Rear I/O: 1 HDMI, 1 DisplayPort, 2 USB 3.1 (1 Type-A, 1 Type-C), 4 USB 3.0, 3 USB 2.0, 1 PS/2, 2 Ethernet, 1 S/PDIF, audio I/O, 1 Clear CMOS button; Form factor: ATX; Warranty: 3 years

CPU overclock or PCIe SSDs in RAID 0, this board has the tools you'll need.

The XPOWER GAMING TITANIUM includes a bunch of goodies to simplify the tuning and tweaking process. Our favorite addition is the OC Dashboard. This daughterboard connects via an extension cable for real-time, push-button control of CPU settings, such as CPU ratio and BCLK. The OC Dashboard also features Power, Reset, Complete Discharge (reset BIOS while PC is off), and GO2BIOS (enter BIOS after reboot) buttons to quickly start afresh. Besides the convenience of not having to reach inside the case, shifting the OC buttons to the daughterboard allows

MSI to provide plenty of space around the board's voltage check point and upper fan headers.

MSI knows that overclocking conveniences aren't much use if the motherboard's power-handling parts are weak. The Z270 XPOWER GAMING TITANIUM is built with MSI's premium Military Class components, 16-phase digital power delivery, and an extra power connectors for the CPU socket and graphics card slots. For CPU power, the board includes both 8-pin and 4-pin connectors, while the PEG slots can supplement power via a 6-pin PCIe connector. Another handy GPU addition is the PCI CeaseFire switch



to enable or disable the PCIe slots, which lets you troubleshoot a problem without physically removing the GPU.

Storage support on the Z270 XPOWER GAMING TITANIUM is outstanding; there are three M.2 slots that support both PCIe and SATA SSDs at speeds up to 32Gbps. MSI includes an M.2 Genie feature in the BIOS to easily create a RAID configuration with your PCIe SSDs. To help you get the most speed from a single M.2 drive, you can install the included M.2 Shield, which MSI says helps to prevent thermal throttling. There's also an U.2 port, if you want to connect a 2.5-inch Intel SSD 750 Series drive. Eight 6Gbps ports are

available, though some will become unavailable when you connect a PCIe SSD. The user's manual provides a detailed chart that shows what ports will be unavailable with all possible storage combinations.

We can't imagine many people, even power users, who will use all the USB connections on the Z270 XPOWER GAMING TITANIUM. The rear panel alone has two USB 3.1 ports (one Type-A, one Type-C), four USB 3.0, and three USB 2.0. One of the USB 2.0 ports serves as a BIOS Flashback port when the PC is unbootable or if you don't want to connect a CPU or memory. For front panel connectivity, there are two USB 2.0 and two USB

3.0 headers. If, for some reason, you need more internal USB 2.0 headers, MSI also provides a USB Xpander daughterboard (and an expander cable) to turn a single header into four USB 2.0 headers.

MSI's TITANIUM edition motherboards have a distinct look with a lustrous silver PCB, heatsinks, and rear I/O cover. The Z270X GAMING TITANIUM also includes an RGB LED header to let you control the LED colors with 5050 RGB LED strips. MSI Mystic Light is also compatible with a variety of other products, including some cases, memory, mice, and keyboards, so you can sync internal and external lighting.

In our benchmark testing, the Z270 XPOWER GAMING TITANIUM did exceptionally well in SiSoftware Sandra's processor tests with top numbers in all the Processor Arithmetic and Processor Multi-Media tests. The board also posted near top results in Cinebench 15 (974 points) and POV-Ray 3.7 (2096.85 pixels per second). Last but not certainly not least, the XPOWER GAMING TITANIUM produced the top overall score in 3DMark's Fire Strike Extreme, boosted by a Physics score of 14524.

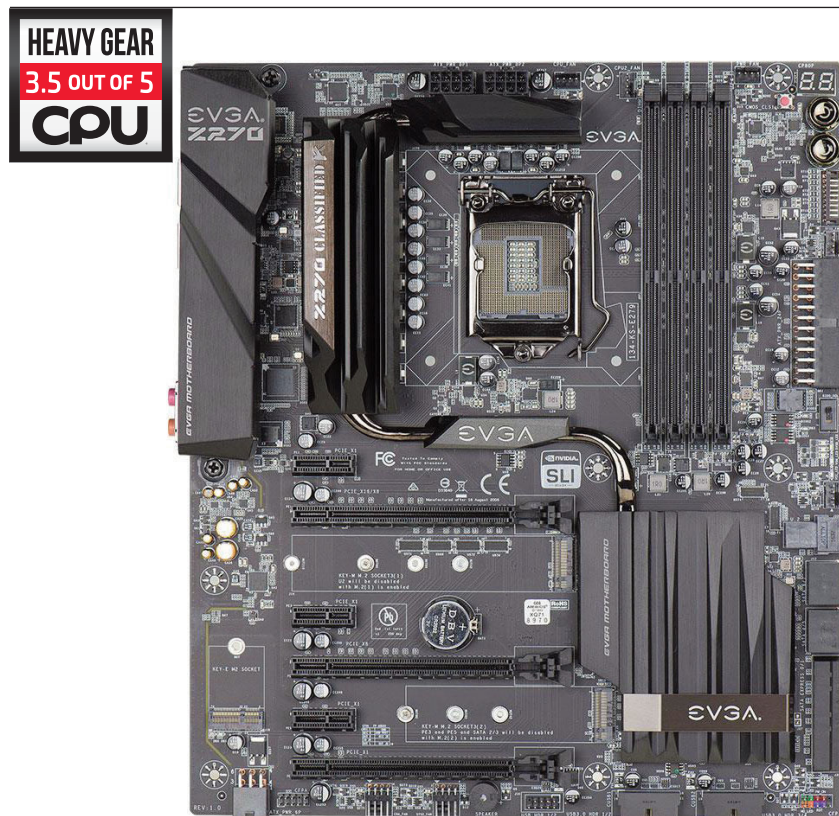
MSI provides a lot of gadgets for overclockers with the Z270 XPOWER GAMING TITANIUM, and enthusiasts will find few Z270 boards as well as equipped for real-time OC control. We also like the impressive storage amenities, as well as the sheer number and variety of USB connections. As you might expect, there's a bit of added cost with the OC and connectivity extras, but the board's \$329.99 retail price is not out of line with what MSI delivers.

## EVGA Z270 Classified K

EVGA's motherboard family is as consistent, from chipset to chipset, as there is. The lineup almost always has three models: the Stinger or Micro (a small form factor board), the FTW (a feature-filled board with additions for

## Z270 CLASSIFIED K

\$299.99 | EVGA | [www.evga.com](http://www.evga.com)



**Specs:** Max memory: 64GB DDR4 (DDR4-2400; Max OC: DDR4-3600); Slots: 3 PCIe 3.0 x16, 3 PCIe x1; Storage: 3 M.2 (2 type 2242/2260/2280/22110, 1 type 1630/2230/3030), 1 U.2, 8 6Gbps SATA, 2 SATA Express; Rear I/O: 1 HDMI, 1 DisplayPort, 1 Thunderbolt 3, 2 USB 3.1 (1 Type-A, 1 Type-C), 4 USB 3.0, 2 Ethernet, 1 S/PDIF, audio I/O, 1 Clear CMOS button; Form factor: EATX; Warranty: 3 years

gamers), and the Classified (built with high-end features and overclocking goodies). The Z270 Classified K continues EVGA's engineering excellence with a 13-phase digital VRM with a CPU socket powered by two 8-pin EPS headers. Clean power to your CPU is just the start, as EVGA includes some of its tried-and-true overclocking favorites. EZ Voltage read points and Probe It connectors, for instance, let you easily attach and hold multimeter leads, and the E-LEET tuning suite is a great tweaking tool.

The Z270 Classified K boasts some of the biggest VRM and PCH heatsinks we've seen, and EVGA runs a metal heat pipe between the giant heatsinks. EVGA says the heat pipes help to distribute heat among the onboard cooling. To simplify the overclocking process, there are onboard power, reset, and clear CMOS buttons, as well as a BIOS switch. Troubleshooting is easy, too, thanks to a series of onboard LEDs that indicate whether slots are active and operating correctly.

As a big-name graphics card vendor, it only makes sense for EVGA to optimize the board's GPU performance. The Z270 Classified K supports 2-way SLI and 2-way CrossFire. On the bottom of the board, there's also a 6-pin PCIe power header that EVGA recommends you use with SLI or CrossFire configurations. The 6-pin connector augments the power provided by the 24-pin to improve stability. A third PCIe x16 slot is also available, but this slot is only wired for x1 speed. It's a bit of an odd choice to electrically wire this slot for x1, as many Z270 motherboards wire the slot at x4 speed—allowing for support of add-in card PCIe SSDs.

EVGA's storage choices are similar to the other models in this roundup. There are two M.2 slots (1 type 2242/2260/2280/22110 and one type 2242/2260/2280), a U.2 port, eight 6Gbps ports, and two SATA Express ports. The top M.2 slot shares

bandwidth with the U.2 slot. Unlike some other boards, you'll need to manually disable or enable the ports in the BIOS, rather than having one automatically shut off if the other shared port is populated. On our test unit, we had to enable the top M.2 slot, as the U.2 port was enabled by default in the BIOS.

In addition to the two Key M (110mm and 80mm) M.2 slots, EVGA provides a Key-E (32mm) M.2 slot that you can use for a Wi-Fi module, or other Key E M.2 device. Wired network connectivity is provided by two NICs—the Killer E2500 and Intel's i219V. The two wired Ethernet ports don't support teaming, but if you add a Killer Wireless AC 1535 or 1525 wireless module, it will work with the E2500 to enable Killer's DoubleShot technology, which prioritizes network traffic and sends latency-sensitive gaming and voice traffic over whichever interface is currently faster.

The Z270 Classified has the most robust rear-panel connectivity of the boards in our roundup, including a full-fledged Thunderbolt 3 port and a USB 3.1 Type-C port. Typically, motherboards only have one or the other, and it's nice to see both on the rear panel. EVGA also includes a USB 3.1 Type-A port and four USB 3.0 ports. An additional four USB 3.0 ports and two USB 2.0 ports are available via internal headers.

The Z270 Classified K is an EATX motherboard, while the other boards in this roundup are the traditional ATX form factor. In addition to the larger form factor, EVGA opts for 90 degree connectors for many of the internal headers, such as the 24-pin main power and USB 3.0 headers. The design makes for a clean look, as it's easier to hide the trailing cables, but might cause an issue if there's limited space around your motherboard. In our test system, for example, there's a PSU shroud that sits directly below board and made it difficult the case's front panel USB 3.0 connector.

Benchmark results for the EVGA Classified K were, for the most part, consistent with the field. SiSoftware Sandra's Memory Bandwidth tests were the notable exceptions, as the Z270 Classified K was the only board to deliver better than 36GBps in both memory-intensive tests. The EVGA Classified K also posted the best frame rate (23.09fps) in the 3DMark Fire Strike Extreme Combined Test, which stresses both the system CPU and GPU.

The Z270 Classified K is an excellent platform for overclocking your Skylake or Kaby Lake processor, and the \$299.99 price tag is a bit more affordable than MSI's Z270 XPOWER GAMING TITANIUM. EVGA does make a questionable choice of wiring the bottom PCIe 3.0 x16 slot for x1 speed. The design might handcuff add-in cards, such as some PCIe SSD options that require four lanes of PCIe 3.0 bandwidth, but this might not be a problem if you only plan to use M.2 or U.2 ports for high-speed storage.

### AORUS GA-Z270X-Gaming 7

The GA-Z270X-Gaming 7 is the most affordable motherboard in this roundup, but device support, onboard connectivity, and visual aesthetics are generally on par or better than the competition. You can create a RAID array, for example, with three PCIe, NVMe SSDs. A triple-NVMe configuration can include PCIe SSDs in the two M.2 slots and the U.2 port or one M.2, one U.2, and one PCIe add-in card. Want high-speed memory? You can install modules running at 4,133MHz. GIGABYTE also provides an abundance of RGB LEDs, which can be split into multiple zones, for gorgeous, custom illumination.

AORUS motherboards have only been around since January, and thus far, prodigious customization has been one of the more defining characteristics of GIGABYTE's premium gaming brand. Take the onboard audio, for example. The



GA-Z270X-Gaming 7 comes with Creative's Sound Core3D quad-core audio processor, as well as Creative's SBX Pro Studio suite that lets you tailor sound quality to your personal preference. A lot of motherboard makers would stop there, but GIGABYTE also adds its AMP-UP technology where you adapt onboard sound quality by installing a different operational amplifier. The GA-Z270X-Gaming 7 includes a switch to adjust gain for 600-ohm headphones, too.

Fan control is another area where the GA-Z270X-Gaming 7 excels. AORUS provides eight hybrid fan/water pump headers that support both PWM and voltage modes. The mainboard will automatically detect what type of device is connected and supply the appropriate power. You can tweak header power modes and create custom fan curves for each header. Two of the headers support up to 24-watt liquid-cooling pumps. For accurate temperature readings, AORUS includes seven temperature sensors and two headers for external temperature sensors. You can configure which sensors the fan headers monitor for optimal cooling and noise.

The AORUS GA-Z270X-Gaming 7 is designed to handle potent overlocks with a 12-phase VRM. To make overclocking easier, the mainboard includes clear CMOS, power, and reset buttons, as well as voltage measurement points and GIGABYTE's UEFI DualBIOS. GIGABYTE has also worked with EKWB to create an optional monoblock, which cools both the CPU and MOSFETs—an interesting option for anyone going the custom loop route.

The expansion slot layout is similar to previous AORUS and GIGABYTE Z270 motherboards we've seen. There are three PCIe 3.0 x16 slots with the top two slots able to run at x8/x8 when two GPUs are installed. The board provides two slots' worth of space between the top and middle PCIe x16 slots, a layout that gives the cards in

an SLI or CrossFire setup room to breathe. The bottom PCIe x16 slot is electrically wired for x4 speed and shares bandwidth with the bottom M.2 slot. This slot operates at x2 speed if you install an M.2 SSD in the bottom M.2 slot.

We already mentioned the extensive RAID options for high-speed storage, and GIGABYTE supplements the PCIe SSD connectivity with six 6Gbps SATA ports, which double as three SATA Express ports. For external storage and general connectivity, the rear panel offers a Thunderbolt 3 port, a USB 3.1 Type-A port, and five USB 3.0 ports. The Thunderbolt 3 port can also serve as a USB 3.1 Type-C port. Similar to

other boards in this roundup, the rear panel offers two Ethernet ports; one is powered by Intel's i219V and the other is driven by Killer's E2500. The latter pairs with the Killer Control Center to prioritize bandwidth to games and apps.

With top marks in 3DMark's Fire Strike Extreme test, PCMark 8's Creative test, Cinebench 15, and POV-Ray 3.7, the AORUS GA-Z270X-Gaming was a definite winner in our benchmark tests. Storage speed with Patriot's 480GB HellFire were scorching, too, with a 2,778MBps Sequential Read (Q32T1) and 797.3MBps 4K Read (Q32T1) in CrystalDiskMark.

It might not have quite as extensive a lineup of OC bells and whistles as the

#### AORUS GA-Z270X-Gaming 7

\$239.99 | GIGABYTE | [www.aorus.com](http://www.aorus.com)



**Specs:** Max memory: 64GB DDR4 (DDR4-2400; Max OC: DDR4-4133); Slots: 3 PCIe 3.0 x16, 3 PCIe x1; Storage: 2 M.2 (1 type 2242/2260/2280/22110/ 1 type 2242/2260/2280), 1 U.2, 6 6Gbps SATA, 3 SATA Express; Rear I/O: 1 HDMI, 1 DisplayPort, 1 Thunderbolt 3, 1 USB 3.1 (Type-A), 5 USB 3.0, 1 PS/2, 2 Ethernet, 1 S/PDIF, audio I/O; Form factor: ATX; Warranty: 3 years

MSI or EVGA boards in this roundup, but the GA-Z270X-Gaming 7 is still pretty accommodating to overclockers, and in addition offers plenty in the performance department. And with a \$239.99 MSRP, the GA-Z270X-Gaming 7 represents an excellent value to power users. It's a complete platform with ideal support for high-speed memory and storage, as well as first-rate onboard audio and I/O connectivity. GIGABYTE tops off the enthusiast additions with stunning RGB LEDs that let the board look as good as it performs.

## An Enthusiast-Grade Collection

During our time testing these motherboards, we found no issues that would be a deal breaker. The AORUS GA-Z270X-Gaming 7 easily wins the award for best price-performance combination. And Extreme overclockers should take a long hard look at both the MSI Z270 XPOWER GAMING TITANIUM and EVGA Z270 Classified K due to the impressive onboard power handling and OC tools. The Supermicro C7Z270-PG also warrants strong consideration from multi-GPU fanatics. In short, there's no wrong choice with this group. ■

BY NATHAN LAKE

Benchmark Results	Supermicro C7Z270-PG	MSI Z270 XPOWER GAMING TITANIUM	EVGA Z270 Classified K	AORUS GA-Z270X-Gaming 7
MSRP	\$339	\$329.99	\$299.99	\$239.99
3DMark Fire Strike Extreme	10004	10139	10077	10121
Graphics Score	10817	11026	10955	11049
Physics Score	14002	14524	14120	14095
Graphics Test 1	58.1	58.21	57.46	58.38
Graphics Test 2	40.7	40.76	40.67	40.81
PCMark 8				
Creative Score	5814	6010	5859	6041
SiSoftware Sandra 2016				
Dhrystone AVX2 (GIPS)	201.77	207.74	200.3	206
Whetstone AVX (GFLOPS)	118	122.4	119.17	121.92
Multi-Media Integer AVX2 x32 (Mpixels/s)	565.32	591.67	576.7	591.46
Multi-Media Long-int AVX2 x16 (Mpixels/s)	199.58	214.61	209.52	214.1
Multi-Media Quad ALU x1 (Mpixels/s)	2.23	2.4	2.33	2.24
Integer B/F AVX/128 (GBps, memory bandwidth)	35.41	35.77	36.5	35.4
Floating B/F AVX/128 (GBps, memory bandwidth)	35.73	36.15	36.67	36.2
CrystalDiskMark 5.1.2 (MBps)				
Sequential Read (Q32T1)	2773	2749	2665	2778
Sequential Write (Q32T1)	1305	1200	1285	1398
Random 4K Read (Q32T1)	750.7	787.8	715.8	797.3
Random 4K Write (Q32T1)	618.5	632.8	627.9	640.3
POV-Ray 3.7 (Pixels/s)	2071.43	2096.85	2089.43	2113.08
Cinebench 15 (Points)	971	974	970	979
Games (2,560 x 1,440)				
Metro: Last Light (Very High, 16xAF; SSAA off)	107fps	106fps	106fps	107fps
Dying Light (High, AO On, AA On, Vsync Off)	119fps	118fps	119fps	118fps
Witcher 3: Wild Hunt (Vsync Off, Unl. FPS, Ultra)	86fps	85fps	86fps	86fps



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## AORUS GA-AX370-Gaming 5

Everybody loves a comeback story. It's been a long time since AMD was truly competitive in the enthusiast processor market, but AMD's Ryzen CPUs look to be a triumphant return for Team Red. And while Ryzen processors play the role of returning hero, the X370 chipset is the hyper-competent sidekick that makes everything go. X370 brings AMD up to speed with the features and connectivity in line with Intel's recent chipset. There are a few other new chipsets with Ryzen, including B350, A320, X300, and A300, but the X370 chipset is the one for enthusiasts. The AORUS GA-AX370-Gaming 5 is one of the top motherboards for the X370 chipset.

It's always easier to see where a motherboard maker has made tweaks if we know the stock chipset features. To start, Ryzen's dual-channel memory controller and the X370 chipset bring AMD into the DDR4 era with stock speeds up to DDR4-2667. The AORUS GA-AX370-Gaming 5 ups DRAM frequencies to DDR4-3200, though we were instructed to run our HyperX Predator DDR4-3200 kit at 2933MHz.

**CPU RANKING** 0 = ABSOLUTELY WORTHLESS 2.5 = ABSOLUTELY AVERAGE 5 = ABSOLUTELY PERFECT

AMD is working with motherboard vendors to work out the kinks, and you can expect upcoming BIOS updates from all mainboard manufacturers to unlock faster speeds down the line. In general, it's wise to check the qualified vendors list to ensure motherboard compatibility, and it's always a smart move when dealing with a brand new chipset.

The X370 chipset, by default, supports 2-way CrossFire and SLI graphics card configurations. Ryzen processors provide 16 PCIe 3.0 lanes for graphics duties, so a CrossFire or SLI configuration will run at x8/x8 speeds, while a single GPU runs at x16 speed. Support for SLI on X370 is notable, as it's not available on AMD's B350 chipset. Many B350 chipset motherboards support CrossFire, but thus far, it looks like the second PCIe x16 slot is typically wired for x4 speed. The AORUS GA-AX370-Gaming 5 also allows for quad GPU configurations if you install a set of dual-GPU cards. Overall, multiple-GPU support on the X370 chipset is similar to what you'll find in the Z270 chipset.

In addition to the 16 PCIe 3.0 GPU lanes, AMD Ryzen processors provide

four PCIe 3.0 lanes for PCIe, NVMe SSDs. It's a smart decision on AMD's part, because you won't have to worry about a PCIe SSD sharing bandwidth with I/O devices or expansion slots powered by the chipset. The X370 chipset itself natively supports up to four SATA ports (in RAID 0, 1, and 10 configurations) and two SATA Express ports. AMD also provides eight, general purpose PCIe 2.0 lanes that can be used for additional connectivity. Overall storage connectivity isn't as robust as Intel's Z270, but it will only affect those who want to set up a RAID with two or more PCIe SSDs.

The AORUS GA-AX370-Gaming 5 is an excellent example of how motherboard makers can utilize the Ryzen processor and X370 chipset to enhance overall storage connectivity. There's an M.2 slot and U.2 slot for PCIe SSDs, but due to the limited PCIe 3.0 lanes for storage duties, the M.2 connector will be disabled if you populate the U.2 port. On the plus side, the M.2 slot supports type 2242/2260/2280/22110 M.2 form factors, as well as PCIe SSDs and SATA





SSDs, so it'll work with any M.2 storage. There are eight 6Gbps SATA ports with RAID functionality and the obligatory two SATA Express ports.

Ryzen processors and the X370 chipset both provide native USB connectivity. The X370 chipset features 2 USB 3.1 ports, six USB 3.0 ports, and six USB 2.0 ports, while the Ryzen processor also chips in four USB 3.0 ports. AORUS ups the USB 3.1 count by installing an ASMedia USB 3.1 controller that provides one USB 3.1 Type-C port and one USB 3.1 Type-A port. There are more than enough USB ports to go around, even for peripheral-heavy power users.

To help you get the most out of Ryzen processors—all of which are overclockable—AORUS uses a 6+4 phase power delivery design hosted by 4th generation IR (International Rectifier) digital power controllers with 3rd generation PowIRstage ICs. The latter can sense current and distribute thermal loads to prevent overheating, which should improve overclocking capability. You can fine-tune voltages, frequencies, and any other OC settings inside the BIOS.

If you read our review of the AORUS GA-Z270X-Gaming 5, the onboard

additions for RGB lighting and fan controls should come as no surprise. The RGB Fusion LEDs, which include LEDs between the DIMMs, under the PCIe slots, and along the sides of the PCB, are just as dazzling with the X370 chipset as they were on Z270. There's also an RGBW LED strip extension header to sync the RGB Fusion lighting with third-party RGB LED kits. The Smart Fan 5 headers will automatically detect the type of cooling device you've plugged in, and AORUS lets you customize fan speeds based on the nine different temperature sensors around the board.

The benchmark numbers showcase what you can accomplish with the Ryzen 7 1800X processor and a high-end X370 motherboard. In POV-Ray 3.7, our test system produced 3288.48 pixels per second, while Cinebench 15 delivered a score of 1616. By comparison, the Core i7-7700K tested in an AORUS GA-Z270X-Gaming 5 produced marks of 2021.79 (POV-Ray 3.7) and 942 (Cinebench 15). Results in our gaming tests, such as 89fps in the Witcher, and 3DMark's Fire Strike Extreme benchmark show no dropoff in GPU results, either.

Geared for enthusiasts, Ryzen processors need a motherboard that will match the impressive CPU performance. AORUS gives power users all the connectivity they need to build a benchmark destroying system. We also like the onboard lighting and fan speed amenities, as it's easy to create a system that runs quietly and looks stunning. Hopefully, BIOS updates will soon be available to improve memory compatibility for high-speed DDR4. ■

BY NATHAN LAKE



Benchmark Results	AORUS GA-AX370-Gaming 5
3DMark Fire Strike Extreme	10491
Graphics Score	11158
Physics Score	18966
PCMark 8	
Creative Score	6201
SiSoftware Sandra 2016	
Dhrystone AVX2 (GIPS)	302.71
Whetstone AVX (GFLOPS)	193.24
Multi-Media Integer AVX2 x32 (Mpixels/s)	559.26
Multi-Media Long-int AVX2 x16 (Mpixels/s)	169
Multi-Media Quad ALU x1 (Mpixels/s)	3.71
Floating B/F AVX/128 (GBps, mem bandwidth)	32.83
CrystalDiskMark 5.1.2 (MBps)	
Sequential Read (Q32T1)	2746
Sequential Write (Q32T1)	1407
Random 4K Read (Q32T1)	752
Random 4K Write (Q32T1)	614.3
POV-Ray 3.7 (Pixels/s)	3288.48
Cinebench 15 (Points)	1616
Games	(2,560 x 1,440)
Metro: Last Light (Very High, 16xAF, SSAA off)	109fps
Dying Light (High, AO On, AA On, Vsync Off)	115fps
Witcher 3: Wild Hunt (Vsync Off, Unl. FPS, Ultra)	89fps

**Specs:** Max memory: 64GB DDR4 (DDR4-2667; Max OC: DDR4-3200); Slots: 3 PCIe 3.0 x16, 3 PCIe x1; Storage: 1 M.2 (slot 1 supports 2242/2260/2280/22110), 1 U.2, 8 6Gbps SATA, 2 SATA Express; Rear I/O: 1 HDMI, 4 USB 3.1 (1 Type-C, 3 Type-A), 6 USB 3.0, 1 PS/2, Ethernet, 1 S/PDIF, audio I/O; Form factor: ATX; Warranty: 3 years

**Test System Specs:** Processor: AMD Ryzen 7 1800X; GPU: GIGABYTE GeForce GTX 1080 Xtreme Gaming; Memory: 16GB HyperX Predator DDR4-3200; Storage: Patriot Hellfire 480GB; OS: Windows 10 Enterprise

HEAVY GEAR  
4.0 OUT OF 5  
CPU



## AMD Ryzen 7 1800X

For the last decade, every Intel processor review used the previous generation Intel processor as the primary point of reference, because AMD couldn't compete. With Ryzen, all of that changes. The Ryzen 7 1800X isn't the second coming of the Athlon 64, but it's a massive pivot-and-leap in the right direction.

Codenamed Summit Ridge, the Ryzen 7 flagship features a 192mm<sup>2</sup> die consisting of 4.8 billion transistors. It is manufactured on Global Foundry's 14nm FinFET process and features eight cores with SMT (simultaneous multi-threading) enabled, letting each core tackle two threads at once, for a total of 16 threads when the processor is running flat-out.

Its core clock is set to 3.6GHz, and it relies on a collection of SenseMI (the MI stands for Machine Intelligence) technologies that enable a Precision Boost frequency of up to 4GHz. We'll dig much deeper

into what SenseMI is all about in the White Paper in this issue, but for the sake of brevity, this lets all eight cores of the Ryzen 7 1800X boost its core frequency, in 25MHz increments, to up to 3.7GHz when the power envelope allows. Beyond

that, two of the most active cores are capable of jumping to 4GHz. For users who install high quality aftermarket CPU coolers that can handle the extra thermal capacity, AMD's Extended Frequency Range (XFR) technology kicks in to give those two cores another 100MHz to play with in short bursts.

For the new architecture, AMD's initial goal was to improve IPC (instructions per clock) by 40% compared to Bulldozer, but AMD's engineers managed a better-than-expected 52% improvement. To keep this powerful processor fed with data, the Ryzen 7 1800X has 32KB of L1 data cache, 64KB L1 instruction cache, and 512KB L2 cache for each core. Additionally, there's an 8MB block of L3 cache shared between all cores.



AMD's new Ryzen is the company's first platform in several years to offer serious competition at the high end for Intel's Core processors. The initial rollout for Ryzen includes three processors, the 1800X, 1700X, and 1700, that AMD has priced very aggressively in relation to Intel's products.

**CPU RANKING** 0 = ABSOLUTELY WORTHLESS 2.5 = ABSOLUTELY AVERAGE 5 = ABSOLUTELY PERFECT



This is a 95-watt processor that features an onboard dual-channel DDR4 memory controller that supports speeds up to 2,666MHz (which is also the speed we tested at). Most AM4 X370 motherboards support memory frequencies up to 3,200MHz, and a simple BIOS update is all that's required.

All of the Ryzen processors will have unlocked multipliers, which gives overclockers who're sick of being asked to pay Intel's K Series "overclocker's tax" a viable high-performance alternative. As

you can see from the scores, the 4.1GHz overclock (across all cores) can make a substantial difference in applications.

The Ryzen 7 1800X is a disruptive product, and as such, it's hard to find a direct competitor from Intel. The significantly less expensive \$350 Core i7-7700K has half as many cores and slightly better single-core performance, but the Intel Core i7-5960X costs more than twice as much, and

comes with a quad-channel memory controller. For enthusiasts who're not running memory-constrained applications, the eight-core, 16-thread Ryzen 7 1800X offers a whole performance bang for your buck. ■

BY ANDREW LEIBMAN

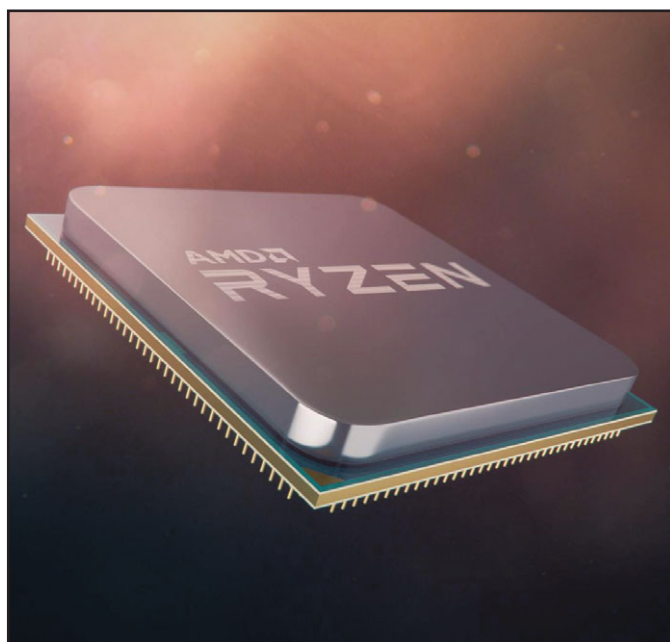


#### Ryzen 7 1800X

\$499

AMD

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	Core i7-7700K	Ryzen 7 1800X	4.1GHz OC
<b>3DMark Fire Strike Ext.</b>	10,073	10,430	10,557
Graphics Score	11,054	11,125	11,125
Physics Score	13,418	18,605	21,181
Graphics Test 1	58.46fps	58.5fps	58.78
Graphics Test 2	40.8fps	41.09fps	41.09
Physics Test	42.6fps	59.07fps	67.24
Combined Test	22.98fps	23.03fps	23
<b>PCMark 8 Creative Score</b>	5,900	6,118	6,351
<b>Sandra 2016 Lite</b>			
Dhrystone Integer Native AVX2 (GIPS)	206.44	302.56	334.5
Whetstone Single-float Native AVX (GFLOPS)	121.55	195	216.13
x32 Multi-Media Integer AVX2 (Mpixels per second)	582.86	572.2	619.51
x16 Multi-Media Long-int AVX2 (Mpixels per second)	214.08	166.19	184.62
x1 Multi-Media Quad ALU (Mpixels per second)	2.39	3.73	4.23
x16 Multi-Media Single-float FMA (Mpixels per second)	506.27	552	600.49
Integer Memory Bandwidth B/F AVX/128 (GBps)	35.93	31.52	31.66
Float Memory Bandwidth B/F AVX/128 (GBps)	36	31.59	31.62
<b>Cinebench 15 (Points)</b>	942	1624	1790
<b>POV-Ray 3.7 (Pxxps)</b>	2,021.78	3398.33	3733.23
Sniper Elite 4 (Vsync Off, Ultra, DX11)	N/A	120.31fps	120.31
The Witcher 3 (Vsync off, Unl.fps, Ultra)	87.6fps	80.53fps	82.71

**Test System Specs:** Processor: AMD Ryzen 7 1800X (3.6GHz Base, 4GHz P. Boost); Graphics Card: GIGABYTE GTX 1080 Xtreme Gaming; RAM: Corsair Vengeance LPX16GB DDR4-3000 (clocked at 2667MHz); Storage: 240GB Kingston HyperX SSD; OS: Windows 10 Enterprise 64-bit



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## NVIDIA GTX 1080 Ti Founders Edition

Gamers following the graphics card tit for tat between NVIDIA and AMD for the last few years have enjoyed the fruits of this intense competition, yielding technologies like SLI and CrossFireX, G-SYNC and FreeSync, HairWorks and TressFX, PhysX, Eyefinity, the Mantle API (now the Vulkan API), Async Compute, Simultaneous Multi-projection, HBM, VR, and countless more. All of which have in one way or another, made games look and play better. The latest salvo from NVIDIA comes in the form of the GeForce GTX 1080 Ti, a preemptive strike designed to deflate AMD's upcoming Vega launch and secure the performance crown.

To craft this card, NVIDIA took the 12 billion transistor GP102 manufactured on TSMC's 16nm FinFET process –the same GPU used in the jaw-droppingly powerful Pascal TITAN X– and tweaked it, raised some clocks, lopped off a little memory, and ended up with an enthusiast gamer's dream. The GeForce GTX 1080

Ti is faster than the TITAN X, but sells for the GTX 1080 Founders Edition's initial price of \$699. As a result, the GTX 1080 is getting a price cut to \$499.



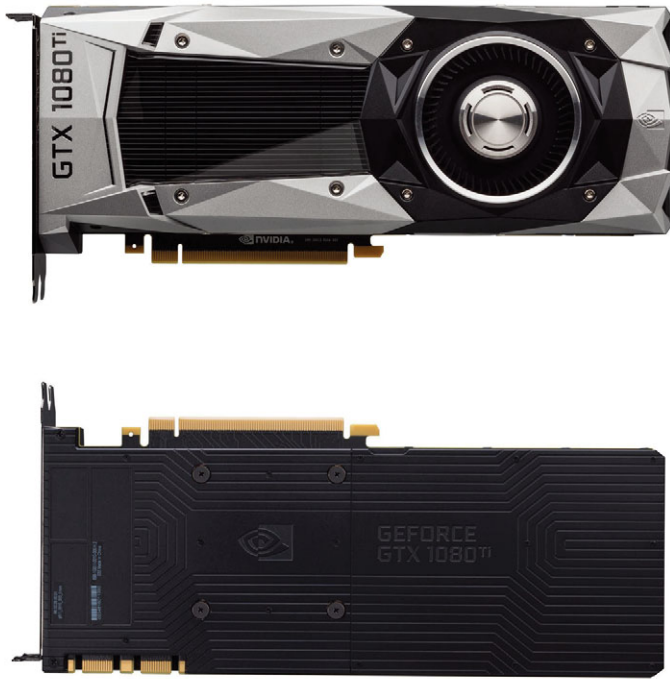
The GPU in this card has everything that makes Pascal one of the best architectures to ever come out of Santa Clara, only more of it. There are 28 Streaming Multiprocessors, 3,584 CUDA Cores, 224 texture units, and 88 ROPs. There's a 352-bit memory bus connected to 11GB of Micron's uber-fast GDDR5X. The TITAN X has a wider 384-bit memory bus, 12GB of GDDR5X and 96 ROPs. The GTX 1080

Ti makes up for the specs deficit with higher core clocks (1,480MHz base, 1,582MHz Boost) and a higher memory clock (11,000MHz effective), which work out to 11.4TFLOPS of peak compute and 484GBps memory bandwidth for a 0.4TFLOP and 4GBps memory bandwidth edge compared to the TITAN X. When compared to the very capable GTX 1080, the new card is 35% faster.

The blower-style cooler attached to the GTX 1080 Ti Founders Edition is nearly identical to the one on NVIDIA's in-house GTX 1080. The card is slightly longer at 11-inches from the bracket to the opposite end near the power ports, and 4.4-inches from the PCIe interface to the green LED-lit GeForce GTX logo. Its width matches that of the bracket, so users with tight enclosures can breathe a sigh of relief. The shroud on this card is composed of a handful of interlocking triangular black and silver die cast aluminum parts adorned with a pattern of various sized

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triangles. There's also a black two-part aluminum back plate that NVIDIA recommends removing a portion of to improve cooling performance when running SLI in adjacent slots. Underneath the shroud, there is a rectangular block of aluminum fins built on top of a large vapor-chamber baseplate, which uses phase changing liquid coolant to rapidly draw heat away from the GPU's die surface.

The GTX 1080 Ti features a new 7-phase 2x dual-FET power design that provides the GPU with 250 amps of power. There are 8-pin and 6-pin PCIe power ports on the top edge of the card. NVIDIA's engineers removed the bulky DVI output riser on the back bracket, which let them double the airflow area. That's a good thing considering that this is a 250-watt card with a thermal threshold of 91 degrees

C. Under load, this card does get a bit noisier than most of the open-shroud GTX 1080s that we've tested.

Outputs include three full-sized DisplayPort 1.4 and one full-sized HDMI 2.0b ports, though the Founders Edition package includes an active DP to DVI adapter for those who are still running DVI monitors.

If you're a 4K gamer, then this is the best card you can buy to get 60fps at max settings in most everything you play. Everything else is a cakewalk for this monster. ■

BY ANDREW LEIBMAN

Specs & Scores	NVIDIA GeForce GTX 1080 F.E.	NVIDIA GeForce GTX 1080 Ti F.E.
Base clock	1,607MHz	1,480MHz
Boost clock	1,733MHz	1,582MHz
Memory clock	2,500MHz	2,753MHz
Memory interface	256-bit	352-bit
Memory	8GB GDDR5X	11GB GDDR5X
<b>3DMark Fire Strike Ex.</b>	9,292	11,806
Graphics Score	9,844	13,304
Physics Score	16,038	24,781
<b>Games</b>	<b>(1,920 x 1,080)</b>	
Shadow Of Mordor (Vsync Off, Ultra, DoF, OIT, Tess)	118.6	195.35
Metro: Last Light (DX11, V High, 16XAF, V High Tess.)	125.33	167.33
Dying Light (High, AO On, AA On, Vsync Off)	128.19	222.29
Witcher 3: Wild Hunt (Vsync off, Unl. fps, Ultra)	80.4	146.29
	<b>(2,560 x 1,440)</b>	
Shadow Of Mordor (Vsync Off, Ultra, DoF, OIT, Tess)	79.65	145.58
Metro: Last Light (DX11, V High, 16XAF, V High Tess.)	84.67	113.33
Dying Light (High, AO On, AA On, Vsync Off)	87.96	163.04
Witcher 3: Wild Hunt (Vsync off, Unl. fps, Ultra)	54.6	109.74
	<b>(3,840 x 2,160)</b>	
Shadow Of Mordor (Vsync Off, Ultra, DoF, OIT, Tess)	39.77	79.76
Metro: Last Light (DX11, V High, 16XAF, V High Tess.)	45.33	67
Dying Light (High, AO On, AA On, Vsync Off)	48.83	79.48
Witcher 3: Wild Hunt (Vsync off, Unl. fps, Ultra)	36.24	59.87

**Specs:** 28 Streaming Multiprocessors; 3,584 CUDA Cores; 224 texture units; 88 ROPs; Clock speed: 1,480MHz base (1,582MHz Boost); 11GB GDDR5X memory (11,010MHz effective); 352-bit memory bus; 250W TDP; 3 Display Port & 1 HDMI outputs

**Test System Specs:** Processor: Intel Core i7-6950X; Motherboard: GIGABYTE GA-X99-Ultra Gaming; Memory: 16GB HyperX Predator DDR4-3000; Storage: 240GB OCZ Vertex 3 MAX IOPS SSD; OS: Windows 10 Enterprise

**B250M MORTAR ARCTIC**

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## MSI B250M MORTAR ARCTIC

In the last few years, we've seen a distinct change in the approach motherboard makers take regarding the "B" variant, such as B150 or B250, of Intel's mainstream chipsets. Rather than rely on the traditional set of business class features, some "B" chipset motherboards now include gaming features, such as high-fidelity onboard audio and a wired NIC that optimizes network bandwidth. Gaming motherboards based on the B150 chipset offered good value (most options retail for less than \$100), but B150 boards were notably handcuffed by the chipsets meager eight PCIe 3.0 lanes. On the B250 chipset, Intel adds four more PCIe 3.0 lanes that support Intel's Rapid Storage Technology, which paves the way for more PCIe SSD options.

MSI's B250M MORTAR ARCTIC is an mATX motherboard that makes near perfect use of what's available on the B250 chipset. There are two PCIe x16 slots, which support CrossFire at x16/x4 speed, and four DIMM slots where you can install up to 64GB of system

memory. The board is compatible with ultra-fast M.2 storage devices, thanks to a 32Gbps Turbo M.2 slot that supports type 2242/2260/2280/22110 form factors. There are also six 6Gbps SATA ports, as well as support for Intel Optane hardware. The connectivity is close to what you'll find on entry-level Z270 motherboards, but MSI only retails the B250M MORTAR ARCTIC for \$89.99.

There are some things the B250 chipset won't support. Overclocking with unlocked CPUs, for example, is out, as is support for memory operating faster than DDR4-2400. The 2400MHz memory speed is only possible with a 7th Generation Intel processor, and 6th Generation chips limit you to DDR4-2133. SLI and RAID configurations are

also unavailable on the B250 chipset. With these caveats in mind, the B250M MORTAR ARCTIC is still a capable platform for a full-fledged gaming PC, especially considering MSI's hardware and software additions.

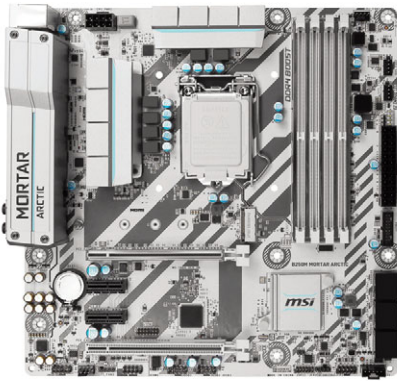
MSI equips the B250M MORTAR ARCTIC with its collection of Audio Boost hardware for studio-grade sound quality. Like many gaming motherboards, MSI physically isolates the audio components and circuitry from the rest of the hardware for a clean path. Chemi-Con audio capacitors handle both the rear and front audio outputs and help to produce rich, deep tones. Realtek's ALC892 processes onboard audio and can deliver up to 7.1 surround sound.

To provide the most bandwidth to users while gaming, the motherboard comes with Intel's i219V LAN port and MSI's GAMING LAN MANAGER utility. The latter allows you to prioritize network bandwidth to your PC's games and applications. By default, the software will detect your games and automatically



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give them priority over other applications. You can customize bandwidth to each program on your PC, should you wish. The Intel i219V LAN port is also shielded against power surges by MSI's LAN PROTECT technology.

MSI includes a couple of software utilities that are helpful to the gaming experience. The Gaming Hotkey utility, for instance, allows you to set up macros, assign commands, and create profiles to customize the functionality of any keyboard. To customize your mouse, MSI also includes a Mouse Master utility where you adjust mouse DPI and program macros to mouse buttons. To take advantage of the mouse and keyboard upgrades, just connect your gaming peripherals to the GAMING Device ports (1 PS/2, two USB 2.0) at the top of the rear I/O panel.

Speaking of the rear I/O, USB connectivity on the B250M MORTAR ARCTIC isn't quite as robust as you'll find on a Z270 motherboard, but that's a function of the B250 chipset, more than a failure on MSI's part. The B250M MORTAR ARCTIC boasts three USB 3.0 Type-A ports and one USB 3.0 Type-C port, as well as two USB 2.0

ports. Comparably priced B250 boards feature nearly identical rear panel connectivity. MSI also provides an X-Boost utility that, according to the company, can boost USB performance by up to 20%.

As part of MSI's Arsenal lineup, the B250M MORTAR ARCTIC gets the camouflage treatment, and being an ARCTIC model, the PCB blends white and silver elements throughout the PCB, heatsinks, and slots. It's a good visual backdrop inside a system, though we'd prefer if MSI switched out the black PCIe x1 slots, SATA ports, and power connectors with white or silver accents to complete the look.

We tested the B250M MORTAR ARCTIC with the high-end collection of parts we use for Z270 chipset motherboards, including a Core i7-7700K, GIGABYTE's GeForce GTX 1080 Xtreme Gaming, 32GB of Corsair Vengeance LED DDR4-3200 (clocked at 2400MHz), and a 480GB Patriot Hellfire. Overall numbers were comparable to the high-end Z270 boards we've tested, highlighted by a 3DMark Fire Strike Extreme score of 10071 and a POV-Ray 3.7 mark of 2092.25 pixels per second.

Small motherboard form factors, such as mATX and Mini-ITX, are an excellent fit for the B250 chipset, as the PCB confines already limit expansion slots and extra power handling for overclocking enhancements. As you can see from our benchmarks, you can make a potent gaming PC with the B250M MORTAR ARCTIC. And with the cash saved, you can devote some extra budget to other parts of your PC. ■

BY NATHAN LAKE

**Specs:** Max memory: 64GB DDR4 (DDR4-2400); Slots: 2 PCIe 3.0 x16, 2 PCIe 3.0 x1; Storage: 1 M.2 (type 2242/2260/2280/22110), 6 6Gbps SATA; Rear I/O: 1 HDMI, 1 DisplayPort, 1 DVI-D, 4 USB 3.0 (1 Type-C, 3 Type-A), 2 USB 2.0, 1 PS/2, 1 Ethernet, audio I/O; Form factor: mATX; Warranty: 3 years

**Test System Specs:** Processor: Intel Core i7-7700K; GPU: GIGABYTE GeForce GTX 1080 Xtreme Gaming; Memory: 32GB Corsair Vengeance LED 32GB DDR4-3200MHz (clocked at 2400MHz); Storage: Patriot Hellfire 480GB; OS: Windows 10 Enterprise

Benchmark Results	MSI B250M MORTAR ARCTIC
3DMark Fire Strike Extreme	10071
Graphics Score	10989
Physics Score	13774
PCMark 8	
Creative Score	5850
SiSoftware Sandra 2016	
Dhrystone AVX2 (GIPS)	199.69
Whetstone AVX (GFLOPS)	118.42
Multi-Media Integer AVX2 x32 (Mpixels/s)	573.61
Multi-Media Long-int AVX2 x16 (Mpixels/s)	207.82
Multi-Media Quad ALU x1 (Mpixels/s)	2.19
Floating B/F AVX/128 (GBps, mem bandwidth)	28.3
CrystalDiskMark 5.1.2 (MBps)	
Sequential Read (Q32T1)	2700
Sequential Write (Q32T1)	1267
Random 4K Read (Q32T1)	755.8
Random 4K Write (Q32T1)	605.1
POV-Ray 3.7 (Pixels/s)	2092.25
Cinebench 15 (Points)	934
Games	(2,560 x 1,440)
Metro: Last Light (Very High, 16xAF, SSAA off)	104fps
Dying Light (High, AO On, AA On, Vsync Off)	110fps
Witcher 3: Wild Hunt (Vsync Off, Unl. FPS, Ultra)	81fps

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## be quiet! Pure Power 10 600W CM

be quiet! has a diverse power supply lineup. There are two high-end series, the Dark Power Pro and Straight Power, as well as several lineups for price conscious builders, such as the Pure Power series we examine here. The German company recently announced Pure Power 10 models, available in either modular or hardwired cabling, that boast several internal improvements while retaining the same low cost of the previous generation. New DC-to-DC power conversion technology, for example, allows Pure Power 10 PSUs to deliver tighter voltage regulation under heavy loads for better overall stability. The affordable PSU is also up to 89.5% efficient and meets the 80 PLUS Silver certification.

The Pure Power 10 600W CM (short for cable management) is one of the modular options in the new lineup, which also includes 700W CM, 500W CM, and 400W CM versions. Despite being geared toward budget builders, the Pure Power 10 600W CM doesn't skimp on dependability features. be quiet! improves reliability by including both active clamp and synchronous rectifier technology, which reduces switching losses and boosts efficiency. There are two +12V rails (one

32A, one 28A) with protections for overcurrent, overvoltage, undervoltage, overpower, overtemperature, and short-circuit conditions.

be quiet! designs the Pure Power 10 600W CM to support multi-GPU gaming rigs. The two +12V rails support a maximum current of 48A for a combined power of 576 watts. That's 96% of the PSU's maximum continuous power. In terms of power distribution, the 32A +12V rail handles the 20+4-pin main power, connected drives, and two of the PCIe 6+2-pin connectors. The 28A rail powers the 4+4-pin CPU power connector and a second set of PCIe 6+2-pin connectors. The unit's +3.3V rail can handle up to 25A and the +5V rail supports 18A.

Similar to previous Pure Power models we've reviewed, the Pure Power 10 600W is semi-modular, but only the 20+4-pin and 4+4-pin connectors are hardwired. In any modern build, of course, you'll need both of the hardwired connectors. The remaining connections are provided via flat black ribbon cables. In total, the Pure Power 10 600W offers four PCIe 6+2-pin connectors, six SATA, three Molex, and one FDD connector. Some comparably priced PSUs offer more SATA and Molex

connectors, but the Pure Power 10 600W's connectivity should be enough for the majority of builds.

As with any be quiet! PSU, the unit comes with the company's Silent Wings fan. The 120mm temperature controlled fan is rated for only 20.3dB(A) when the PSU is under full load, and at 50% load, noise levels drop to 12.5dB(A). In our testing, the Pure Power 10 600W CM was never audible over the other components in our case. We were able to push the power supply to a maximum wattage of 355 with a power factor of .971 by simultaneously running Prime95's In-Place test and Unigine Heaven 4.0. Power factor, under load, was typically between .960 and .985.

Affordable cost might be the most compelling reason to purchase the Pure Power 10 600W CM, yet the PSU's internal switching hardware also makes reliability part of the value proposition. A couple more SATA and Molex connectors would be nice, but barring a large RAID array or multiple Molex powered fans, the connectivity shouldn't be a problem. ■

BY NATHAN LAKE

**Specs:** Maximum wattage (continuous): 600W; 12V rails: 2 (32A, 28A); +5V max: 18A; +3.3V max: 25A; Efficiency rating (advertised): 80 PLUS Silver; Fan: 120mm; Connectors: 1 x 20+4-pin ATX, 1 x 4+4-pin EPS12V, 4 x 6+2-pin PCIe, 6 x SATA, 3 x Molex, 1 x FDD; Warranty: 3 years

**Test System Specs:** Processor: Intel Core i7-7700K; Motherboard: MSI B250M MORTAR ARCTIC; GPU: GIGABYTE GeForce GTX 1080 Xtreme Gaming; Memory: Corsair Vengeance LED 16GB DDR4-3200MHz (clocked at 2400MHz); Storage: 480GB Patriot Hellfire; OS: Windows 10 Enterprise

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## Rosewill EX-700 Hybrid 2-Way In-Ear Headphones

If a company wanted to make a splash with its first entry in what's already a packed pool of high-end earbuds, it could do worse than take the path Rosewill did with its new EX-700. Rosewill opted to do something unique. With the EX-700, this translates to using a driver that's not only uncommon in this price range, but also highly effective, including at widening the so-called audio soundstage. Whereas many earbuds' one-driver approach effectively mashes instruments and vocals together to dull their individual personalities, the EX-700's hybrid driver creates ample space for instruments to breathe with clarity. Combine this with a handsomely rugged exterior and tantalizing price and the Hi-Res Audio logo-bearing EX-700 is a solid match for discerning listeners.

For the EX-700, Rosewill combined an 8mm dynamic driver designed to tackle the low end with a balanced armature driver that does the same for mids and highs. Together, Rosewill says the unit can

deliver lossless 24-bit/192k audio; reach 40kHz; and output trebles, mids, and lows that work together but stand apart. (A new EX-500 model also uses a hybrid driver, although it combines a 10mm dynamic unit with a ceramic tweeter.) Aiding all this is usage of OFC (oxygen free copper), a gold-plated 3.5mm plug, and patented "SpinFit" ear tips. The latter are designed to sit deeper in the ear canal to better isolate noise and thus enhance treble. The effect was noticeable but only slightly so for me. Rosewill bundles three sets of these ear tips along with two standard sets.

While all these touches are appreciated, ultimately the proof is in the pudding. To that end, the EX-700 outputs some fine-tasting pudding. Most satisfying was the extent to which mids were present in music listening. Rather than emphasizing lows or highs and thus muddying the mids, the EX-700 presents a cleanliness and preciseness across the audio spectrum that's wonderful. In Steely

Dan's "Gaucho," which has tons going on musically below the surface, the EX-700 enabled keyboards, backing vocals, horns, chimes, and more to ripple and flow. In Massive Attack's "Teardrop," which starts with a crisp, isolated beat before layers of additional sounds gradually join in, the earbuds ably captured the track's simmering intensity. Succinctly, any mid-priced earbuds that can create the sense of being in the room as The Beach Boys harmonize on "God Only Knows" is worth strong consideration.

Elsewhere, the EX-700's gunmetal-gray aluminum-alloy housing looks stealthy cool but should take a good beating over time. Also fetching is the twisted-wire cord that's wrapped in a transparent protective layer. Looks and durability aside, though, the EX-700's best feature is the top-notch audio it delivers for its price, which sits at \$49.99 online. ■

BY BLAINE FLAMIG

**Specs:** Driver: Hybrid driver combining one balanced armature driver and one 8mm dynamic driver; Frequency response: 20Hz to 40kHz; Impedance: 26 ohms; Sensitivity: 102dB +/- 3dB @ 1kHz; Mic: Sensitivity: -42dB; Controller: In-line with call-answering; Connector: gold-plated 3.5mm; Extras: 3.93-foot twisted wire, carrying pouch, standard and patented ear tips

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## Zalman ZM-K900M White Edition

It's pretty easy to see with a glance around your favorite PC parts retailer and/or any LAN party you go to that these days, LED lighting is king. Putting LEDs on computer parts and peripherals isn't a new thing, of course, as it's been going on for many years, but starting in late 2015 and into 2016, component and peripheral companies really began shifting LED inclusion into high gear. You'll find LEDs on every component of some builds these days, and several motherboard manufacturers have begun to include control systems for tying all those lights together under one control interface.

White PC components are also quite popular, and Zalman has seemingly accounted for both of these factors in designing its ZM-K900M White Edition mechanical gaming keyboard. Let's just get this out of the way: The ZM-K900M White Edition is hands-down the brightest, most colorful keyboard we've ever seen. Depending on how your tastes run, that could be an asset or a liability, but for those who like their PC parts shiny and bright, this one's right up your alley.

Zalman designed the ZM-K900M with per-key RGB backlighting, which illuminates

not only the space beneath and around the key, but also lights up the letter or number etched into each keycap, and when you plug it in for the first time right out of the box, a rainbow of colored light flows continually across the keyboard from left to right. You can customize the backlight in many ways, setting the full keyboard backlight to run one of 13 preset effects or selecting only specific keys to light up. You can even have your selected keys light up in a specific order, and you can of course also control the brightness of the LED backlight. And that's not all: The ZM-K900M's backlight can even respond to your keystrokes if you want it to.

In addition, Zalman equipped the keyboard with 10 preset game profiles that light up selected keys for several game genres (FPS, MMO, MOBA, RTS) and several specific games, including Counter-Strike, DOTA 2, StarCraft 2, and others.

We should also point out that there's more to this keyboard than pretty lights. It's a full 104-key QWERTY model with 10-key numpad and media control keys, and Zalman offers it with Kailh Blue or Brown mechanical keyswitches. Our review unit came with the Brown switches, which provide

tactile feedback but aren't clacky, so we liked them and so did our nearby colleagues. The ZM-K900M is part of Zalman's Z-Machine Gaming Gear line, and its Z-Engine system gives the board a high 1,000MHz polling rate, which according to Zalman results in a 1ms response time.

Other features that help make it a legit gaming keyboard include Z Key mode, which disables the Windows key, full support for macros, N-key rollover, a five-way routing guide groove along the bottom of the board that helps keep the cable out of your way, non-slip rubber pads and adjustable feet for elevating the back end, and a Step Sculpture 2 profile that helps make it comfortable to use for long stretches.

We put the Zalman ZM-K900M White Edition through its paces with several hours of FPS and MMO gaming, and it performed admirably. It's comfortable, responsive, and as mentioned earlier, it's very bright and very colorful. If you're contemplating an all-white gaming build and you want maximum LED presence, this is the keyboard for you, full stop. ■

BY CHRIS TRUMBLE

**Specs:** Switch type: Kailh Blue or Brown mechanical; Polling rate: 1,000MHz; Adjustable RGB LED backlight; full N-key/6-key rollover; 1.7-meter braided nylon cable; Interface: USB (PS2 with included adapter)

**CPU RANKING** 0 = ABSOLUTELY WORTHLESS 2.5 = ABSOLUTELY AVERAGE 5 = ABSOLUTELY PERFECT

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**Viper V361 (lower right) & V370 7.1 (left)**  
**Virtual Surround Headsets**

\$49.99; \$69.99

Patriot

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## Patriot Viper V361 & V370 7.1 Virtual Surround Headsets

**M**ake or break, that's what first impressions can do. If so, Patriot was hardly left broken after debuting its first Viper gaming peripherals in 2015. If anything, the inaugural Viper products quickly positioned Patriot as a contender in the space. The V360 gaming headset belonged to that lineup, and while Patriot still sells it (\$39.99), the V361 and V370 (and V330 stereo model) recently joined the Viper ranks.

Like the V360, the V361 and V370 are 7.1 virtual surround sound models, integrate a Volume dial and UBR (Ultra Bass Response) switch in the left earcup, and include an omnidirectional mic that folds inconspicuously into the headset. The new headsets distinguish themselves with a new housing that relocates the Viper logo to the earcups' front-center and incorporates a wider adjustable headband. Identical-looking, the V361 and V370 create a formidable presence with their matte-black finish and silver and red accents that extend to the 7-foot

braided cord. Further, both headsets' hard-rubberized exterior, steel headband frame, and metal-mesh earcup grilles create a foundation that's durable without compromising comfort.

Elsewhere, both headsets integrate LED lighting around the Viper logos, though the V361 is limited to red while the V370 offers full RGB range and several customization options. Additionally, both headsets forego the V360's onboard LED switch in favor of control via downloadable software. The lighting itself is soft but attractive. Other than differences in software versions for each headset, it's the LED abilities that primarily differentiate them. Otherwise, both headsets use closed-back designs that admirably block environmental noise; omit an inline controller; and pack a 40mm neodymium magnet main driver and 30mm sub-driver in each earcup.

That latter driver fuels Patriot's wonderful UBR function, which adds low-end pizzazz and heightened ambiance

to nearly every listening experience. Further, pushing volume in bass-heavy tracks like The Beastie Boys' "Funky Boss" didn't introduce unacceptable distortion or losses in clarity. While the headsets' discrete drivers and UBR function alone produce above-average audio, activating virtual sound added noticeable flavor and depth, including to engines roaring from all directions in "Mad Max: Fury Road" and horses hooves pounding in The Witcher 3: Wild Hunt.

A minor complaint pertains to the headsets' non-bendable mic boom, which leaves the mic a fair distance from the mouth. Those I communicated with reported OK clarity but noticed some surrounding noise creeping in. That said, both headsets shine considering their prices (particularly the V361) and keep Patriot on a stated path to create gaming peripherals that meet the same level of expectations buyers have for its memory. ■

BY BLAINE FLAMIG

**Specs:** Drivers: 40mm neodymium main driver, 30mm sub driver, 20Hz to 20kHz; Impedance: 32 ohm @ 1kHz; Sensitivity 110db +/- 3dB @ 1kHz; Mic: non-detachable omnidirectional, Frequency response: 100Hz to 10kHz; Sensitivity: -38dB +/- 3dB (V361), -46dB +/- 3dB (V370); Controller: on-earcup volume, UBR switch; Connector: gold-plated USB; Extras: 7-foot braided nylon cable, extra earpads, carrying bag, earpad removal tool



# RIG

## OF THE MONTH

### NCIX PC Avalanche 004



**N**CIX PC's Avalanche 001 won the Intel 2016 Extreme Rig Challenge in a landslide. The Avalanche 001 gathered more than 30,000 votes—6,000 more votes than the second-place finisher.

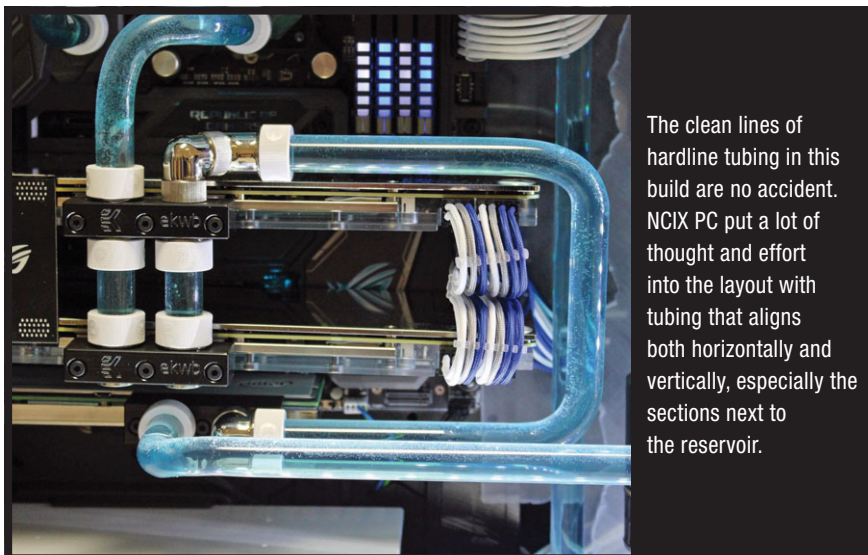
The Avalanche 004 is another model in the limited-edition Avalanche run, and it features a tweaked hardware configuration with many of the 001's extreme liquid-cooling customizations. For

#### Avalanche 004

\$10,000 (as configured)

NCIX PC

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The clean lines of hardline tubing in this build are no accident. NCIX PC put a lot of thought and effort into the layout with tubing that aligns both horizontally and vertically, especially the sections next to the reservoir.

instance, NCIX PC uses EKWB's premium PETG hard tubing in a beautifully crafted loop that cools the motherboard VRMs, CPU, two GPUs, and an Intel 750 Series SSD. NCIX PC quickly dissipates the heat via two EK-CoolStream 360 radiators.

With the Avalanche 004 build, NCIX PC opts for Intel's new Z270 chipset and the Core i7-7700K, rather than the 001's X99 chipset and the Core i7-6950K. The ASUS ROG MAXIMUS IX FORMULA sits at the heart of this desktop PC Mountain. The mainboard's ROG Armor provides a stylish look with black ABS covers that also help to lower system temperatures. The ROG

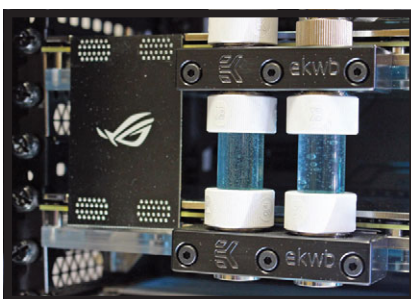
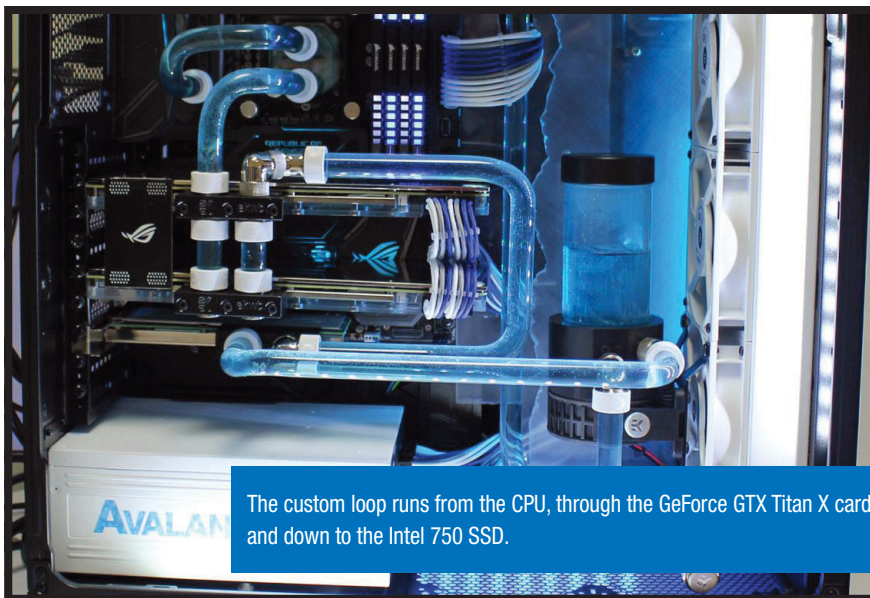
MAXIMUS IX FORMULA also boasts EK's CrossChill II for onboard VRM cooling. G1/4 threads and a copper water channel let CrossChill II effortlessly fit into NCIX PC's cooling loop. The mainboard's Aura Sync LEDs flash a light blue that matches the blue liquid coolant in the clear hardline tubing.

The ROG MAXIMUS IX FORMULA supports up to two-way SLI, and the Avalanche 004 produces some seismic benchmark results by filling the top two PCIe x16 slots with NVIDIA's GeForce GTX Titan X (Pascal) graphics cards. At 3,840 x 2,160 resolution and the highest settings, all of our games tests topped 60fps, including 67fps in Witcher 3. And at 2,560 x 1,440, frame rates were near 150fps or better. The liquid cooling keeps the GeForce GTX Titan's heat in check, and we love the shiny nickel backplates.

### A Beautiful Sight

NCIX PC makes a nice artistic choice with the cooling loop around the GPU. Both GPU waterblocks have parallel pass-throughs (hardline tubing connected to both the left and right sides, rather than one entrance and exit), but instead of routing the liquid out the bottom of the lower GPU, the coolant exits above the top GPU, and NCIX PC creates a rectangular section of hardline tubing that runs around the GPUs and down to the 1.2TB Intel 750 SSD. The top and bottom of this rectangular section are about the same height as the reservoir, which resides a few inches to the right.

In addition to the horizontal symmetry, many of the vertical sections of hardline tubing match up to form exceptionally clean lines. For example, the portion of the loop exiting the front radiator is an unusually long (30 inches) stretch that vertically aligns with a rectangular



Avalanche rigs feature a limited edition number.







The frosted acrylic panels near the motherboard tray further accent the interior with a pulsing blue backdrop.

section near the GPUs. NCIX PC adds LED strip lights along the top and bottom of the case to brightly illuminate the hardline tubing. The aligned tubing and lighting also create a sense of depth that makes the system interior look extremely spacious.

With a name like Avalanche, the bright white and cool blue colors inside the system are the perfect theme. NCIX PC complements the colors with a hand-frosted piece of acrylic behind the reservoir, and the purposeful jagged cuts look like mountain peaks. The exterior and radiators are painted white with a glittery finish that draws the eye. A lot of boutique builders can create a wow factor, but these creative touches show that NCIX PC is thinking on another level with the Avalanche builds.

### We're Happy Tonight

As you might expect from a \$10,000 system, the Avalanche 004 made

mincemeat of our benchmarks. We've already touched on the gaming frame rates, and the GeForce GTX Titan X cards were also remarkable in 3DMark's Fire Strike Extreme (overall score of 20,058) and Fire Strike Ultra (overall score of 12,288) tests. The liquid-cooled 1.2TB Intel 750 SSD posted great numbers in CrystalDiskMark, highlighted by a sequential read (Q32T1) of 2,520MBps and 4K (Q32T1) write of 724.7MBps.

### Walkin' In A Winter Wonderland

The Avalanche systems meet the "Powered By ASUS" certification requirements, allowing NCIX PC to honor warranties on all liquid-cooled parts. We know that not many enthusiasts can afford a \$10,000 system, but if you're looking for the ultimate in performance, appearance, and support, NCIX PC clearly has the expertise to design and build the PC of your dreams. ■

BY NATHAN LAKE

### Specs

Processor: Intel Core i7-7700K; Motherboard: ASUS ROG MAXIMUS IX FORMULA; GPU: NVIDIA GeForce GTX Titan X (Pascal; x2 SLI); RAM: 64GB Corsair VENGEANCE LED DDR4-3000; Storage: 1.2TB Intel SSD 750 Series; PSU: Corsair AX1500i; OS: Windows 10 Home 64-bit; Warranty: 3 years

Benchmark Results	Avalanche 004
3DMark Fire Strike Extreme	
Overall Score	20058
Graphics Score	26946
Physics Score	13886
PCMark 8	
Creative Score	6261
SiSoftware Sandra 2016	
Dhrystone AVX2 (GIPS)	207.16
Whetstone AVX (GFLOPS)	122
Multi-media Integer AVX2 x32 (Mpixels/s)	589
Multi-media Long-int AVX2 x16 (Mpixels/s)	221.11
Multi-media Quad-ALU x1 (Mpixels/s)	2.38
Floating B/F AVX/128 (GBps, mem bandwidth)	522.9
CrystalDiskMark 5.12 (MBps)	
Sequential Read (Q32T1)	2520
Sequential Write (Q32T1)	1229
Random 4K Read (Q32T1)	830.8
Random 4K Write (Q32T1)	724.7
POV-Ray 3.7 (Pixels/s)	2,124
Cinebench 15 (Points)	984
Games	2,560 x 1,440
Metro: Last Light (Very High, 16xAF; SSAA off)	155fps
Dying Light (High, AO On, AA On, Vsync Off)	194fps
Witcher 3: Wild Hunt (Vsync Off, Unl. FPS, Ultra)	145fps
Games	3,840 x 2,160
Metro: Last Light (Very High, 16xAF; SSAA off)	79fps
Dying Light (High, AO On, AA On, Vsync Off)	82fps
Witcher 3: Wild Hunt (Vsync Off, Unl. FPS, Ultra)	67fps

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# FrostByte

**J**on “PennyWise” Hansz first appeared in “Mad Reader Mod” in our May 2012 issue, when his EpiDemic mod won our mod contest at PDXLAN 19, and then he won again one year later at PDXLAN 21 with his Triton mod. In a weird sort of symmetry, he won the mod contest again along with Ron Lee Christianson (with their excellent The Witcher mod) and appeared in our April 2016 issue, and has won once more (also a year later) at PDXLAN 29 with this month’s Mad Reader Mod: FrostByte.

This incredible mod obviously gets its name from the frost dragon sculpted onto the front, top, and right-side panels. “I have been wanting to do a dragon build for quite some time,” Hansz tells us. “I drew all my inspiration for this build from my two daughters, Odessa and Olivia. They don’t know it yet, but this build is for them. I was really impressed with how well they have improved in school this year and how they are taking pride in their grades.”

## Taming A Dragon

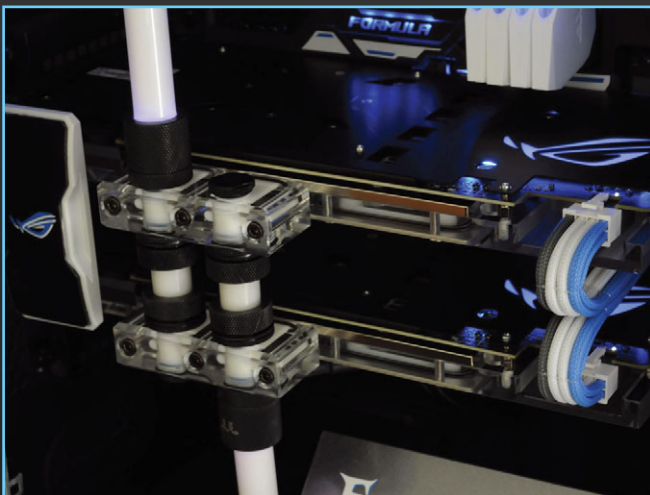
Hansz’s technical skills as a modder have been well demonstrated; he’s an electrician, and his profession has clearly contributed to his skill in working with his projects’ wiring and such. But Hansz says he just began sculpting again last year for the first time since art class in high school;

the result was his and Christianson’s Witcher mod, and he’s back at it again with this project.

FrostByte took Hansz about two months to complete, working mostly on the weekends. “I vacuum-formed the basic shapes of the dragon,” Hansz says. “This saved on material and cut down on the weight of the case. I riveted the forms to the case and built off of them using more styrene and Magic-Sculpt sculpting clay. After finishing all the detail sculpting and sanding, I began the tedious task of painting each scale. I used a combination of airbrush and hand painting, and I painted each scale four times to blend them.

“I mounted the head on the case and ripped the vented front open, making it look like the dragon was tearing through the case. I built the eyes out of frosted acrylic and sculpted them into the face. Then I backlit them to make them glow, and added black vinyl slits.”

Hansz also built all of the cables from scratch and hand-sleeved them, lacing the bundles together with clear fishing line. He added blue and white vinyl pieces throughout the interior to continue the external color scheme, built a custom plaque out of the system’s hard drive, hand-bent all of the tubing for FrostByte’s cooling system, and gave the case a gunmetal paint job with a clear-coat finish.



Additionally, Hansz said he built a makeshift paint booth in his garage for this project using plastic sheeting, a box fan, and a kids' crawl tunnel that he repurposed into ducting to vent the paint fumes outside.

### Teeth & Fangs

FrostByte began as a Thermaltake Core X71 case. Hansz added an Intel Core i7-6700K processor, an ASUS ROG MAXIMUS VIII FORMULA motherboard, 16GB of Avexir Raiden DDR4 memory, a pair of ASUS STRIX GeForce GTX 1070s in SLI, a Thermaltake Toughpower DPS G RGB 1250W power supply, a V-Color 120GB M.2 SSD, and a 2TB Seagate hard drive.

His cooling subsystem consists entirely of Thermaltake parts, including Riing fans, tubing, fittings, RGB fittings, coolant, waterblocks, radiators, and reservoir/pump combos. (The MAXIMUS FORMULA also includes built in EKWB CrossChill EK MOSFET cooling.)

### He'll Be Back

Hansz says he built six mods in 2016 alone, so it should come as a surprise to no one that he will be starting another project shortly. "I haven't started on a personal build yet, but I will have something in the works very soon," he says.

We'd say he's earned a (short) breather. ■

## We Want Your Mod

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## Modder Q&A: Dennis Leach

### Life Before & After Danger Den

Nobody has more modding cred than Dennis “DeadGuy” Leach. One of the co-founders and owners of the legendary case and cooling shop Danger Den, Leach has been making PCs faster, cooler, and better-looking since 2000. After moving on from his first venture, he helped his son Bren and friends start Moonlight Mods, a company with a killer lineup of steel and acrylic cases in all shapes and sizes. Leach won the first *CPU* mod contest at PDXLAN back in 2007 and has appeared twice in *CPU*’s “Mad Reader Mod” feature. He’s been involved with a number of other major modding contests and is still a fixture at PDXLAN in Portland.

**Q:** The first time we bumped into your work was PDXLAN back in 2007 when your Overkill mod won the first mod contest we ever held at PDX. How many PDXLANs have you been to now, and when did you start going?

**DL:** I started going at PDXLAN3. I have only missed one event in 2013.

**Q:** Do you still have Overkill, by the way?

**DL:** That is the one I wish I had kept, but I didn’t. I usually just end up giving away all my project cases when I am done with them. My goal is to build the perfect case; I have yet to get there. But there is always the next one.

**Q:** So Danger Den got started around 2000, right? How long were you into building and modding before you and the guys got DD going?

**DL:** We started watercooling our own rigs about 1998. I would stay after work and use the machining equipment to build waterblocks for Dan, Jeremy, and myself.



**Q:** What was your first mod, and how did you get started modding PCs?

**DL:** If you remember back in the old days of watercooling, we used to use heater cores for radiators and you would usually hang them off the back of the case. I started modding cases so I could hide the heater cores on the inside of the case so no one

would know it was watercooled. When people saw how fast your overclock was, they couldn’t figure out how you did it until you opened the hood.

**Q:** How are you involved with Moonlight Mods now, and are any of the other Danger Den guys part of that?

**DL:** Me and Dan still hang out all the time, but Moonlight Mods is my son’s and myself (family owned). The boys love building custom cases.

**Q:** The second time you were in “Mad Reader Mod” was with your Bench Racer rig, which featured ASUS’ Rampage III Extreme motherboard. How did you find building a mod based on a piece of hardware rather than starting from a concept of your own?

**DL:** That one gave me nightmares. I blame Brian Jang, who worked for ASUS at the time (he’s now with NVIDIA). I was building a custom case for ASUS at the time for PDXLAN, so they could show off the Rampage III. Brian mentioned they had the expander card for it, but it





Leach's first Mad Reader Mod winner, Overkill, graced the cover of the May 2007 issue of *CPU* after it won our mod contest at PDXLAN.

Here's Leach's Bench Racer, his second MRM-winning effort, minus its super-cool red front panel.

was only for bench racing, not meant to be in a case. Like the dummy, I am, I said I could build one! That was only 13 days before the LAN. Only problem was, there were no working cards in the U.S. There was a dead one I could look at, but that was it. The day before PDXLAN started, I got a box from ASUS with all the working parts. I showed up at the LAN with the computer with no OS installed and no drivers. With help from the ASUS and NVIDIA people we got the correct drivers installed and it fired up.

**Q:** We also got to see some of your work during the NVIDIA ION Case Mod Contest, held in conjunction with NVIDIA and Modders-Inc.com. Your entry, ION Bonsai, was definitely the first mod

**we've ever seen that included a real, live bonsai tree! Have you done any projects since then that work in such an unusual element as a tiny, living tree?**

**DL:** That one was actually a really fun one, I had to take someone else's idea for a case, and then build it. The case was part CNC-machined and part wood. It was meant to be a media player for me, but it had to pass the wife test to be in the living room. Which is why Bill Owen won . . . my wife wasn't one of the contest judges. My friend Scott Schuff from [thoselightsigns.com](http://thoselightsigns.com) still has it in his living room. His wife wasn't one of the judges, either.

**Q:** What rig did you game on at the most recent PDX event, PDXLAN 29?

**DL:** ASRock X99E-ITX, Intel 5960X, Sapphire RX480, prototype case.

**Q:** Of all the projects you've worked on over the years, which would you say is your favorite, and why?

**DL:** My favorite case is always the next one I will build. I've always been trying to build the perfect case, and someday I'll do it. It is all about the building.

**Q:** Your son Bren won "Mad Reader Mod" once, as well, in 2009. Have you guys worked on mods together, and—more importantly—did you teach him everything he knows?

**DL:** We work together all the time, last year at PDXLAN we were in the charity mod contest together and



we built a case called Wolf-moon. Our case didn't win the contest, but it raised the most money for the charity and won the popular vote. We were happy with it. And he is more creatively talented than I am. (Don't tell him I said that.)

**Q:** What's your favorite part of every mod project, and what's your least favorite? Why?

**DL:** The best part is when I'm starting the build, and my least favorite part is when it's over and I must clean up. It's all about the designing and building for me.

**Q:** What do you think of the state of modding these days?

**DL:** Modding is alive and doing well, at least in this part of the country. Going to PDXLAN all the time has spoiled me. The number of modded computers there is amazing. The competition is always tough, the best modders in the country will show up here.

**Q:** It's time for Five Quick Questions!

**1) Core or Ryzen?**

Core, but I really want to give Ryzen a try.

**2) Coke or Pepsi?**

Coke.

**3) Ducks or Seahawks?**

That's easy, Oregon State. Go Beavs!

**4) Custom-painted PSU or power supply shroud?**

Shroud.

**5) Counter-Strike: GO or Overwatch?**

Infinite Warfare, dedicated to my [KH] clan, it's all we play. ■



ION Bonsai was Leach's entry in the 2009 NVIDIA ION Case Mod Contest; it strikes a rare balance between technology and nature, to the point where it looks right at home even in an ornate Japanese garden.



Wolf-moon, a project Leach built with his son, Bren.



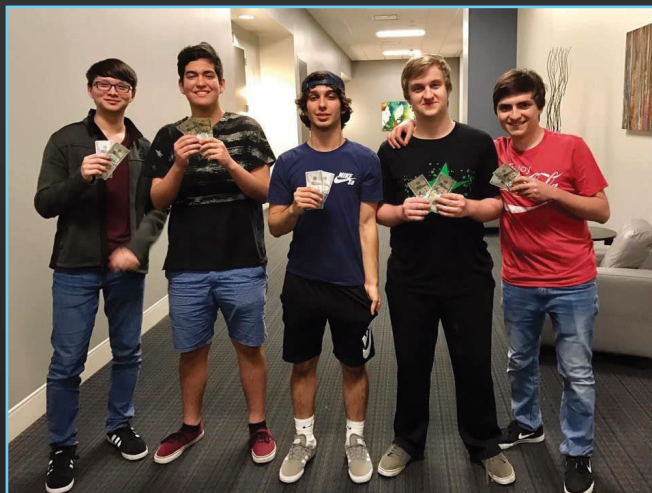
# San Antonio's SAN LAN Spring 2017

## Counter-Strike For Cash, Prizes & A Good Cause

Way back in July 24th, 2003, gamers in the San Antonio area banded together and set up their own Counter-Strike: Global Offensive event, aptly named SAN LAN. Over the years, SAN LAN has hosted events ranging in size from 30 to 200 attendees, and it has been on hiatus for a while, but Harold Bratcher, its lead organizer, says that now it's back for good. "In early 2016 I came across a reddit post where people were talking about our old LAN parties and expressing regret that there's not a similar event taking place in San Antonio anymore," Bratcher says. "It all became clear to me: I needed to bring SAN LAN back in full force." The return of SAN LAN took place last year on August 27th.



The latest SAN LAN event was held on Saturday, March 11 from 8 a.m. to midnight at Norris Conference Centers, and was a traditional 5v5 round-robin CS:GO tournament for a maximum of 10 teams. The entry fee was \$50, and spectators could come and watch the action for \$10. Bratcher says they filled all their tournament seats and had about 25 spectators; teams competed for \$2,000 in cash prizes, as well as a raffle for cool gaming prizes from SAN LAN sponsors, including a state-of-the-art chair from Arozzi, gaming headsets from Arctic, and Gunnar Phantom MLG gaming eyewear.





SAN LAN Spring 2017 was also a benefit event for Animal Defense League of Texas; players and spectators could bring toys, blankets, food, and other pet-related items to benefit the orphaned cats and dogs the League cares for while they wait for new homes. Donating any of the items from the ADL wish list gave attendees extra entries for the prize raffle.

"We have two pets that we adore, a cat and a dog we adopted from the shelter," Bratcher says. "Most of the gamers who attend SAN LAN have pets of their own and love animals, so my wife Ruxandra, who manages SAN LAN's PR and marketing, thought that partnering up with the Animal Defense League of Texas would be a great idea. And she wasn't wrong. The SAN LAN family was very receptive to this charity."



SAN LAN has also held benefits for Toys For Tots, and has another cause in mind for the next event. "We think that veterans, military families, and deployed troops deserve so much more," Bratcher says. "So for our next event, we are working toward partnering up with a non-profit that helps America's heroes."

The Summer 2017 SAN LAN event will be a two-day event, and will include additional activities, including a *CPU Case Mod Contest*, so if you dig CS:GO and you're in the area, stay tuned to [sanlan.org](http://sanlan.org) for more information as it becomes available!







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**RGMP-700**  
Pro Gaming Extended XL Mouse Pad



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# AMD Ryzen

## After A Long Wait, Enthusiasts Get Another Option



**B**y now, you've probably read our Ryzen 7 1800X review, and likely a few others to boot. AMD has come a long way since the glory days of the K8 series processors, and although the Ryzen 7 isn't exactly the equivalent of Rocky Balboa standing over Apollo Creed as the bell dings at the end of the fifteenth round, it is decidedly disruptive, and Intel's definitely been put on notice. AMD's got its groove back and that's fantastic news for computing enthusiasts.

### Some Perspective

Prior to March 2nd, 2017 and for the decade leading up to the launch of AMD's Ryzen 7 processors, Intel dominated the enthusiast CPU landscape. The company's long standing performance lead gave the firm near-complete control over prices, PC technology adoption, and market segmentation. As such, enthusiasts and gamers looking for the best performing processors needed to choose between two platforms, Intel's pricey one where processors with more than four cores and quad-channel memory resided, or the more affordable

mainstream platform where up to 50% of the processor's die was dedicated to an eSports-grade graphics adapter that's rendered redundant when the user installs a discrete graphics card. And gamers are defined by the fact that they typically install a discrete graphics card.

During this period, AMD was always there in Intel's big blue shadow, offering less powerful parts on platforms that were consistently one or two years behind in features and manufacturing processes. This remained the status quo as AMD launched the lackluster K10 and Bulldozer series processors in 2007 and 2011. In mid-2013, Intel launched the 84-watt Haswell Core i7-4770K, which was fast, overclockable, and highly power efficient. AMD's last real stab at the enthusiast market came in the form of a battle-axe, the FX-9590, which is an eight-core monstrosity with a 4.7GHz base clock and a 220-watt TDP. As Intel moved to Skylake, and more recently Kaby Lake, AMD didn't even have a platform that supported DDR4 memory, and AM3+ motherboards that support NVMe and USB3.1 were few and far

between. With DDR4 recently achieving price parity with DDR3, AMD was well and truly left without a competing platform and processor yet again.

Compared to those processors, Ryzen 7 doesn't represent a dramatic shift in AMD's marketing strategy. For about as long as AMD's processors have lagged behind Intel's, AMD has pitted more discrete cores against Intel's two- and four-core processors with and without SMT (simultaneous multithreading), AKA Hyper-Threading. Although AMD's FX Series processors and A Series APUs had plenty of resources at their disposal, they had to rely on high frequencies to







AMD CEO Lisa Su played a big role in driving AMD to create the Zen architecture and ultimately the Ryzen processors.

the cores, a high-bandwidth low-latency cache system, use of the energy-efficient FinFET manufacturing process, and a 2016 availability. Importantly, Bulldozer's CMT (cluster multithreading); which forces multiple cores to share L1, fetch, decode, dispatch, and FPU; was being dumped in favor of SMT (simultaneous multithreading), which dedicates more resources to each core, similar to the design of Intel's processors. As progress continued on the design, more platform goals solidified, including high core counts and no onboard GPU for the enthusiast processors, as well as a new AM4 socket and support for DDR4 memory.

In May 2015, Zen's roadmap had slipped to 2017, but AMD had put out the claim that, largely thanks to the successful implementation of SMT, the new chips would be capable of 40% more IPC than its previous line of FX processors. To put that in perspective a little, consider a 7% IPC gain seems typical between two generations of a semiconductor using the same (or nearly the same) architecture. Compared to the Piledriver-based processors, AMD's Steamroller processors, exemplified by the quad-core A10-7850K APUs, enjoyed a better than 9% single-threaded and 18% multi-threaded IPC improvement. When we first heard that AMD's engineering team was targeting 40% IPC, which put them within striking distance of Intel's Haswell and Broadwell chips, we were cautiously optimistic.

As Zen began to take shape over its four-year gestation period, over 2 million engineering man-hours were spent working on it. The processors were eventually renamed Ryzen, and the first processors to bear that slightly silly-sounding new name would be built for enthusiasts. These initial Ryzen 7 processors would be designed to take on Intel's Core-i7, just as the Ryzen 5s set to launch in April would go toe-to-toe with the Core i5s. You could look at the Ryzen numbering scheme as yet another example of AMD falling in line behind Intel, but now that we've seen for ourselves what Ryzen is capable of, it comes off more

even come close to Intel's chips, and Global Foundries' processes were not tuned to deliver chips that could support such high clocks. Furthermore, most software, even through 2015, was still woefully single-threaded, which put the spotlight on single-core performance and played to Intel's particular strengths. What is different this time is all down to the Ryzen 7 architecture, which closes the IPC (instructions per cycle, the number of operations the CPU can perform within each clock cycle) gap with its rival's products.

### The Right People, & Not A Moment Too Soon

In the world of x86 semiconductor design, it takes a considerable amount of time to scrap an architecture and start from scratch. That's why Intel's been iterating on the Core architecture for seven generations and more than a decade, and it's also why doing so at AMD called for no small amount of house cleaning.

Rory Read was appointed President and CEO in August, 2011 to replace Dirk Meyer, who was instrumental in laying the

groundwork for the Bulldozer chips that failed to result in compelling processors for enthusiasts. Shortly thereafter, Lisa Su came on board as AMD's SVP and General Manager in January of 2012. In 2012, together with AMD's SVP and CTO, Mark Papermaster, Su oversaw the rehiring of Jim Keller as Corporate Vice President and Chief Architect for CPU Cores. Keller, a veteran from AMD's K7 and the lead architect behind the K8 architectures, is largely credited with co-authoring the design of the Hypertransport bus specification, and while at Apple, for the design of the A4 and A5 processors used in the iPhone 4/4S and iPad and iPad 2. Although Keller left AMD before the Ryzen 7 processors saw the light of day, most attribute the success of the new architecture to his designs and leadership. Less than three years after Su came onboard, Read left AMD and Su stepped in as President and CEO.

### Zen's Blank Slate

In 2012, AMD had several goals for their new architecture, including a complete from-the-ground-up redesign of

as an unblinking face-to-face challenge.

At the Ryzen 7 Tech Day, Lisa Su revealed that her team of chip designers had managed to exceed their IPC goal, to the tune of 52% improvement compared to Excavator. The new processors would be led onto the battlefield by the eight-core sixteen-thread Ryzen 7 1800X with a 3.6GHz base clock and a 4GHz boost clock. The Ryzen 1700X would be identical to the flagship, but with a 3.4GHz base and 3.8GHz boost clock. These two would have a 95-watt TDP, but the third processor in the Ryzen lineup is the Ryzen 7 1700, a cooler 65-watt TDP processor that relies on a 3GHz base and 3.7GHz boost clock. Prices for the new processors are \$499 for the flagship, \$399 for the middle-tier unit, and \$329 for the least expensive model. If the Ryzen 7's early performance numbers were enough to get Intel to take notice, then these prices were an old fashioned shot across the bow.

### New Model, New Name

All processors under the Ryzen brand, from mainstream to the prosumer models, will utilize a single numbering scheme. As stated above, the first number refers to the target market; 7 for enthusiast processors, 5 for the high performance chips, and 3 for the mainstream parts. This is followed by a four digit number starting with the generation number, then a number ranging from 4 through 8 to indicate performance level within the segment, and followed up by a double-digit model number. The first generation of Ryzen 7 and 5 processors we know about end with double zeros, but future speed bumps may bear a 50 or 20 in the spot of the model number. Lastly, there is the power suffix, for instance X, which indicates the presence of XFR (eXtended Frequency Range). Other power suffixes that'll be attached to future processors include G (desktop processor with



Although AMD's higher-end Ryzen processors don't ship with CPU coolers, there are several new Wraith coolers available.

onboard graphics), T (low power desktop), S (low power with desktop graphics), H (high performance mobile), U (standard mobile), and M (low power mobile). So when you see "Ryzen 7 1800X" in the headline of a review in CPU, you know we're talking about the best of the first generation top-end AMD processors, with XFR enabled (more on what XFR is all about later).

### Ryzen 7's Insides

The small modular cores of excavator and previous AMD architectures were not a good fit for gamers and enthusiasts, but AMD's Zen architecture shows that AMD knew exactly how to make up the ground they'd lost since the mid-2000s.

Although the architecture has the most the most impact on how efficiently and effectively a given processor runs, the manufacturing process plays a pivotal role. This first generation of Ryzen processors is built on a density-optimized version of Global Foundries' 14nm FinFET process. The last FX processor we took a look at, the FX-8370, was manufactured at a comparatively ancient 32nm process. AMD's engineers used several techniques to ensure that Zen would be a very power efficient platform, including enabling aggressive clock gating with multi-level regions, creating a large micro-op cache

capable of limiting power-sucking faraway fetches, and creating a stack engine that results in low power address generation into the dispatcher.

The onboard memory controller is dual-channel, which puts the Ryzen 7 on par with Intel's Z270 platform, but it's half the bandwidth of the E Series Intel chips running on the X99 platform. Inside each Ryzen 7 processor is a pair of CCX (CPU Complex) units that consist of four cores, each capable of handling two threads, connected to 8MB of 16-way L3 cache, made up of four slices. According to AMD, each core can access every cache with the same average

latency. The 96KB of L1 cache dedicated to each core is split, with 2/3rds for instructions, and the remaining 1/3rd for data. The L2 cache is a 512KB block of 8-way associative memory that is strictly inclusive of the instruction and data caches. The ever-important L2 cache has 32-byte interfaces between it and the L1 and L3 caches.

The Ryzen 7 1800X, as well as the other two Ryzen 7 processors, features two CCX modules for a total of eight cores and 16 threads. In addition to stacking the cores, AMD can also disable individual cores within the CCX, as is the case for the four- and six-core Ryzen 5 processors. It's this flexibility that lets AMD use the Zen architecture for processors in the client, server, and HPC spaces.

Each CCX in the Ryzen 7 relies on what AMD calls the Infinity Fabric, which comprises the interface and bus that lets the modules, cores, and caches communicate with one another and with system memory, I/O, and PCIe devices. AMD also leans on the Infinity Fabric to deliver sophisticated command and control capabilities such as the ability to read real-time core voltage, temperature, power draw, and clockspeed as well as make adjustments to all of the above on demand.





A 52% increase in IPC (instructions per clock) is simply unheard of in a single processor generation.

All told, AMD's new architecture was designed from the outset to address four key ideas, including improved instruction-level parallelism for vastly superior single-threaded performance, lower latency and faster caches and prefetcher engines and support for simultaneous multi-threading, granular active and idle power sensing and control mechanisms, and a modular multi-CCX design on an Infinity Fabric interconnect and interface that lets AMD scale to and integrate features ideal for virtually any segment and market it chooses to serve.

### AMD SenseMI Technology

AMD recently described its SenseMI (Sense Machine Intelligence) as an umbrella of technologies that covers Pure Power, Precision Boost, Extended Frequency Range, Neural Net Prediction, and Smart Prefetch.

The first three of those, Pure Power, Precision Boost, and XFR, all tap into a smart grid of interconnected sensors within each Ryzen processor capable of accurately reporting power and temperatures within 1mA, 1mV, 1mW, and 1 degree Celsius up to a thousand times per second. With this data, the processor can dynamically adjust its performance and power attributes to meet the application demand at hand. Instead of simply copy-pasting the same power profile for every Ryzen processor, Pure Power lets each Ryzen processor tune its power consumption behavior to the silicon's specific capabilities. Precision Boost functions similarly to Intel's Turbo Boost, by raising or lowering the processor's clockspeed in response

to demand and thermal headroom. AMD's scheme lets the processor adjust clockspeeds in 25MHz increments. XFR, available only on Ryzen processors with the X suffix, is an extra bit of speed that the processor can put on that scales to the user's cooling solution. If you're running a closed-loop liquid cooler, then the processor can look at the distance to junction thermal maximums to determine this, then adjust the speed accordingly when possible. If you're working with liquid nitrogen, then the fully automated XFR process should conceivably kick in more often.

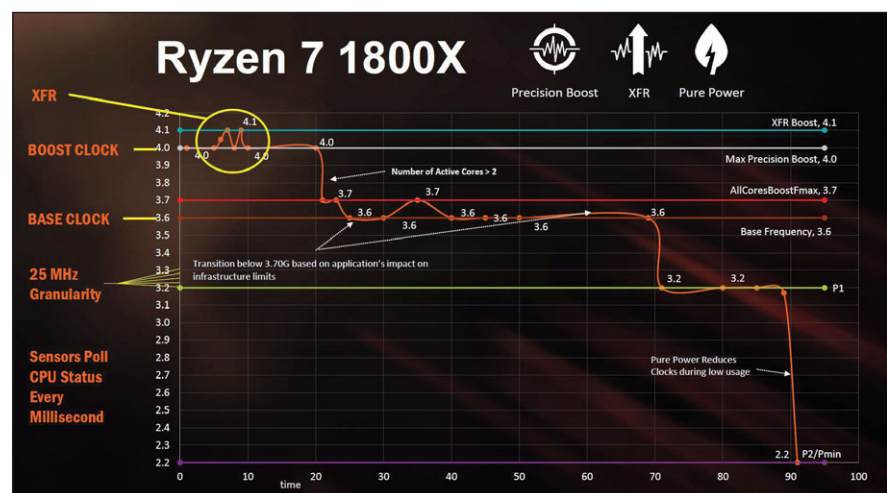
AMD's Neural Net Prediction and Smart Prefetch technologies refer to AI algorithms that the processor uses to analyze and learn application behavior in real-time. With this information, the

Ryzen processor can preload instructions into cache, anticipate the location of future data calls, and determine the best route for data to travel through the processor to execute the task as quickly as possible, every time.

### Ryzen Memory Support

Whenever a new platform launches, memory support, particularly with respect to higher-speed DIMMs, is usually one of the last aspects to fall in line. Often, motherboard reviews get posted with memory running below spec because the BIOS update that adds support for the rated speed has yet to materialize as we go to press. In our Ryzen 7 1800X review, we were running a 3200MHz-rated kit of Corsair Vengeance LPX memory, but the system would only boot with the memory running at 2,667MTps. That's also the upper limit for non-overclocked modules, according to AMD's reviewers' guide. Strangely, when we installed the Ryzen 7 1700X, it ran the same kit at 2,933MTps, without a hitch.

AMD's memory performance numbers are different depending on whether you're using single- or dual-rank DIMMs. Rank refers to the series of DRAM chips that can be accessed at once over the same address and data buses, and there can be multiple ranks per module. Depending on



Ryzen's SenseMI technologies have a big impact on the processor's moment-to-moment frequency and power characteristics.

the application and controller capabilities, some systems can achieve better performance from multi-rank DIMMs, while these can also suffer from a latency penalty due to the fact that only one rank can access the channel bus at a time.

Officially supported memory on AMD's AM4 platform breaks down like this, four dual-rank and single-rank DIMMs are limited to non-overclocked speeds of 1,866MTps and 2,133MTps, respectively. Two module kits of dual-rank and single-rank DIMMs operate at 2,400MTps and 2,667MTps. Although these seem low for DDR4, most motherboards you can buy will support overclocked memory speeds, and that support will get better as time goes on. When shopping for the perfect kit of DDR4, rather than worrying about whether the memory you want to buy is dual- or single-rank—many memory vendors don't tell you this—we recommend paying close attention to the list of qualified memory kits from your motherboard vendor of choice.

According to AMD, Ryzen processors don't offer memory dividers for DDR4-3000 and DDR4-3400. As a result, anyone looking to run the fastest kits should buy memory clocked at 3,200 or 3,500MTps. Robert Hallock, CPU Technology Evangelist at AMD, reports that his internal team have had success running two-DIMM 16GB kits that use Samsung "B-die" memory chips running at 2,933MTps, 3,200MTps, and 3,500MTps. Models include Geil EVO X GEX416GB3200C16DC (16-16-16-36 @ 1.35v), G.Skill Trident Z F4-3200C16D-16GTZR (16-18-18-36 @ 1.35v), and Corsair CMK16GX4M2 B3200C16 VERSION 5.39 (16-18-18-36 @ 1.35v).

### Overclocking FTW

We've said it before, but it bears repeating: Overclocking should not be a feature you have to pay for. By monetizing the unlocking of the multiplier and binning the chips to within nanometers of their thermal envelopes, Intel has systematically sucked the life out of the enthusiast practice. Ryzen

processors, every last one of them, will have an unlocked multiplier. Although overclocking will be limited to the X370 and B350 chipsets, there are plenty of practical reasons for an enthusiast to opt for one of those chipsets over the mainstream overclocking-restricted A320 or small form factor A300. And there's no shortage of affordable X370 and B350 boards to boot.

As we went to press, we only have experience running the Ryzen 7 1800X and the Ryzen 7 1700X, which we managed to overclock to 4.1GHz and 4GHz, respectively. And those numbers are for all eight cores. The Ryzen Master Utility (available at [www.amd.com/en/technologies/ryzen-master](http://www.amd.com/en/technologies/ryzen-master)), is a very competent little utility that serves as a Windows-based software front-end for overclocking your hardware. You can use it to tweak the multiplier, voltage, memory timings and speed. It also lets you keep track of temperatures and real-time speeds, create and manage multiple clocking profiles, and even disable cores to give those who exclusively run poorly-threaded applications more overclocking headroom. Although we'll talk more about the Ryzen Master Utility in an upcoming issue, we can say that we really like the interface, especially compared to the UI disasters that most vendor-specific overclocking and monitoring utilities have become.

It's much more along the lines of Intel's Extreme Tuning Utility and AMD's Polaris overclocking, and both are very easy to use.

As ever, your chances of getting a similar—or better—overclock depend on a combination of your cooling subsystem, the processor's unique thermal properties, and how much you're willing to push your hardware. From what we've seen, 4.2GHz is about as high as you'll be able to achieve with off-the-shelf liquid or air cooling. We raised the voltage from 1.35v to 1.475v to get our best and most stable results, but would advise against adding much more voltage to the processor. Make sure to keep an eye on your power draw, however, as these overclocks can turn your 95-watt processor into one that consumes over 150-watts under a full load.

### Ryzen From The Ashes

We're still in the early days of AMD's seeming resurrection. There are still unanswered questions, particularly on how the Ryzen 5 will stack up against Intel's more affordable processors. AMD has also scheduled updates for April and May that are designed to clear up some of the software and firmware quirks that have popped up. But so far, we think it's safe to say that enthusiasts now have a viable alternative to Intel's CPUs that doesn't come with any asterisks. Indeed, now's a great time to build a new system. ■

**SOCKET AM4 MOTHERBOARDS**  
NEW, HIGH-END OPTIONS



ASRock ASUS BIOSTAR GIGABYTE MSI

There are a slew of high-performance Ryzen boards available to make the perfect foundation for your next build. And by available, we mean hopefully back in stock soon.



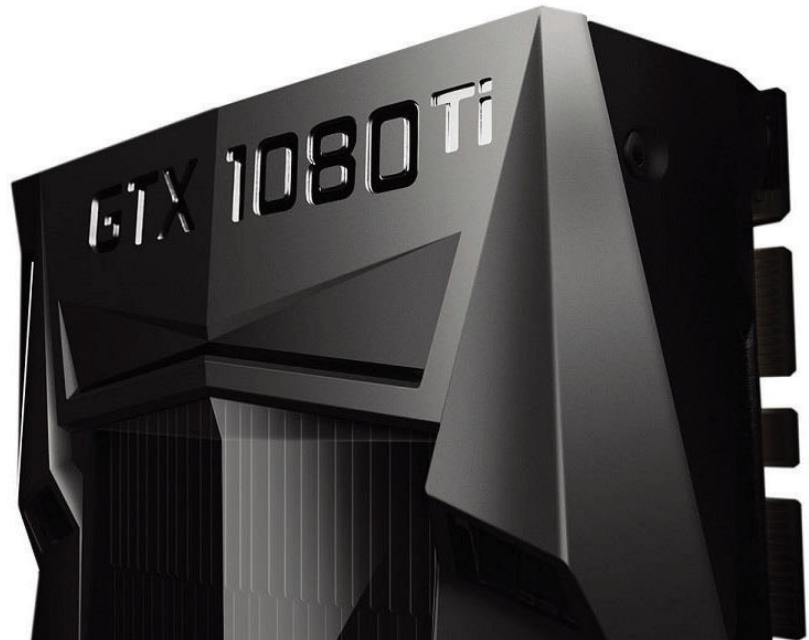
# NVIDIA GeForce GTX 1080 Ti

## Pascal Gets The Titanium Treatment

Flagship graphics cards are more important than ever. Creating “the most powerful GPU on the planet” to win bragging rights and curry favor with PC gamers might still confer a tactical advantage in the perpetual war between Green and Red, but we have now several ways to put all that pixel-pushing horsepower to work. Ever since we entered the age of VR and 4K gaming, there’s been no shortage of opportunities to punish even the fastest graphics cards.

For the last few generations, if you wanted the best NVIDIA graphics card money could buy, your choice was painfully simple: You bought a TITAN. Since they first joined the family with the company’s Kepler micro-architecture, TITAN graphics cards created a “Tier 0” in NVIDIA’s desktop GPU hierarchy. However, TITANs have also been painfully expensive. Never debuting for less than \$999, TITANs have broken records and bank accounts in equal measure. Those unable to put together that much scratch still had a solid backup plan; the best “Ti”-branded cards in any given product family (for example, the GeForce GTX 780 Ti or GTX 980 Ti) were still beasts, even if they couldn’t trade punches with their respective TITANs.

This March at the Game Developer’s Conference in San Francisco, NVIDIA co-founder and CEO Jen-Hsun Huang announced the best possible plot twist when he revealed the GeForce GTX 1080 Ti to the world. Instead of being a modest upgrade over its predecessor, the GTX 1080, the GTX 1080 Ti turned out to match the Pascal-based TITAN X nearly spec for spec. Despite this, Huang announced that the GTX 1080 Ti Founders Edition’s retail price would be \$699—the same as the GTX 1080



NVIDIA brought along some heavy artillery at this year’s Game Developer’s Conference, officially announcing GeForce GTX 1080 Ti. The card immediately takes its place as the undisputed king of the GeForce GTX 10 Series, and it even gives the vaunted TITAN X a run for its money.

Founders Edition when it launched. By comparison, the TITAN X arrived on the scene with an imposing \$1,200 price tag.

Gamers and enthusiasts ready to get behind the wheel of the supercar equivalent of a graphics card now have a remarkable opportunity: They can buy what is arguably the best card on the market for almost half of what the *other* best card originally cost. The GTX 1080 Ti is ready to state its case as this spring’s hottest commodity.

“The GeForce GTX 1080 Ti is for enthusiast gamers who want the very best,” says Brandon Bell, NVIDIA senior technical marketing manager. “With its additional CUDA cores and greater memory footprint and bandwidth, the GTX 1080 Ti particularly excels at 4K

gaming and for gamers driving multiple monitors in surround.”

### Memory Makeover

Whenever a new graphics architecture is revealed, we tend to pay a lot of attention to the GPU itself, as both NVIDIA and AMD are constantly tweaking and refining their graphics processors to deal with increasingly demanding games, heavily parallelized workloads, and other advancements in graphics technologies (such as TressFX or HairWorks). We also eagerly await developments in manufacturing processes, since die shrinks let chip makers pack more transistors in the same space, resulting in cost savings, performance increases, and often both. Maybe, as was the case with the GTX 1080 Founders Edition, we’ll be treated to a radically redesigned cooler and/

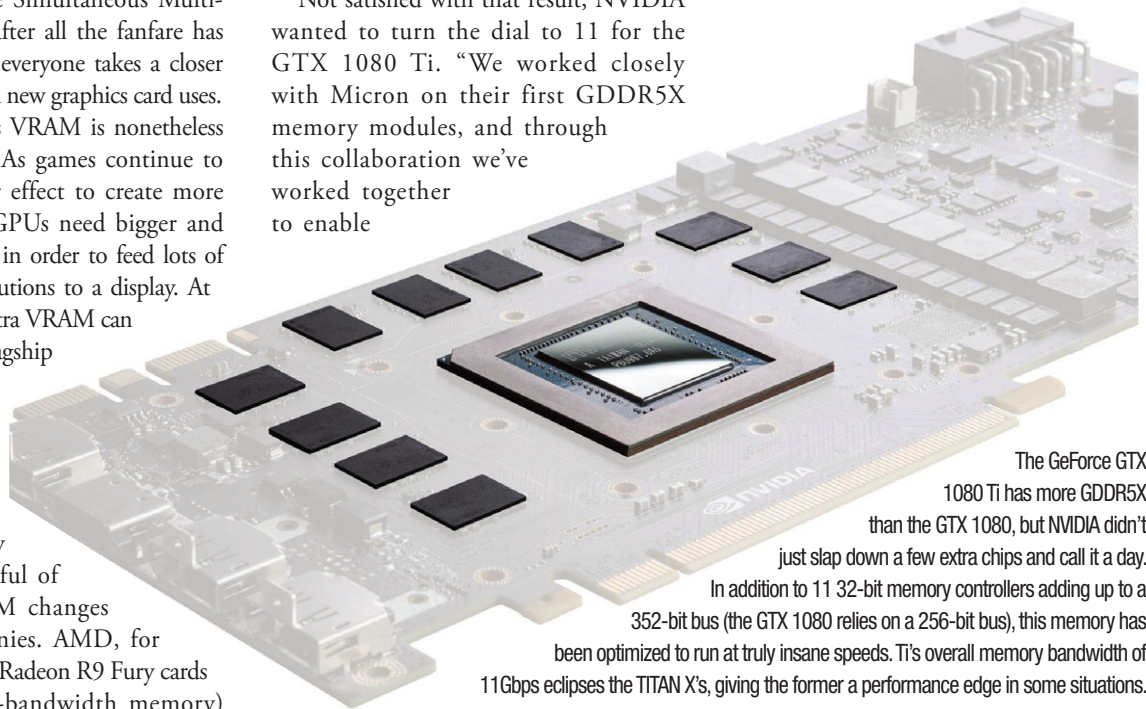
or innovations like Simultaneous Multi-Projection. Then, after all the fanfare has died down, maybe everyone takes a closer look at the VRAM a new graphics card uses.

A graphics card's VRAM is nonetheless a critical element. As games continue to pile on effect after effect to create more stunning visuals, GPUs need bigger and faster frame buffers in order to feed lots of details at high resolutions to a display. At lower resolutions, extra VRAM can go to waste, but flagship graphics cards can always put it to good use.

NVIDIA and AMD understand this, which is why we've seen a handful of noteworthy VRAM changes from both companies. AMD, for instance, stacked its Radeon R9 Fury cards with HBM (high-bandwidth memory) rather than GDDR5, which has been a staple on graphics cards for almost a decade.

The GeForce GTX 1080, GTX 1080 Ti, TITAN X, and the rest of NVIDIA's Pascal-based desktop GPUs rely on GDDR5; for the aforementioned top three cards in the Pascal stack, NVIDIA took its GDDR5 further. A partnership between NVIDIA and Micron ushered in GDDR5X, which, as you might expect, runs faster than GDDR5. The effective memory clock on the GTX 1080 and TITAN X is an impressive 5GHz, resulting in a data rate of 10Gbps.

Not satisfied with that result, NVIDIA wanted to turn the dial to 11 for the GTX 1080 Ti. "We worked closely with Micron on their first GDDR5X memory modules, and through this collaboration we've worked together to enable



The GeForce GTX 1080 Ti has more GDDR5X than the GTX 1080, but NVIDIA didn't just slap down a few extra chips and call it a day.

In addition to 11 32-bit memory controllers adding up to a 352-bit bus (the GTX 1080 relies on a 256-bit bus), this memory has been optimized to run at truly insane speeds. Ti's overall memory bandwidth of 11Gbps eclipses the TITAN X's, giving the former a performance edge in some situations.

faster 11Gbps memory," Bell says.

The original GDDR5X, first introduced on the GTX 1080 and later on the TITAN X, couldn't handle an 11Gbps data rate. At such lofty speeds, the memory simply wasn't reliable. After putting their heads together, engineers at Micron and NVIDIA devised a package of changes that cleaned up the memory interface signaling. According to official documentation, NVIDIA "refined the data channel to the DRAM,

used advanced equalization techniques to reduce adverse effects of the physical interface, and minimized jitter and noise." Together, the modifications let NVIDIA ratchet up the GTX 1080 Ti's GDDR5X effective clock to 5,500MHz, good for an 11Gbps data rate.

The GTX 1080 Ti also boasts more VRAM than the GTX 1080—an extra 3GB. Considering the GTX 1080 Ti's similarities with the TITAN X, however, you could also argue that NVIDIA simply lopped off 1GB of GDDR5X from the TITAN X. (A glance at the GTX 1080 Ti board image above makes the latter notion even more convincing.) Possessing 11GB of GDDR5X to the TITAN X's 12GB would normally put the GTX 1080 Ti at a disadvantage, but the GTX 1080 Ti's improved GDDR5X balances the scales. With its new VRAM and a 352-bit bus, the GTX 1080 Ti musters a maximum memory bandwidth of 484GBps. By comparison, the TITAN X's 480GBps falls slightly short.

As a Pascal GPU, the GTX 1080 Ti has a few other tricks up its sleeve, which helps it wring even more performance



Alas, the venerable DVI port didn't make the cut on the GeForce GTX 1080 Ti's backplane, but the payoff is worth it, we think. By removing the DVI port, NVIDIA was able to increase the exhaust area for the cooler, resulting in twice as much airflow compared to the GeForce GTX 1080 Founder's Edition.



## FLAGSHIPS YOUNG &amp; OLD

	GTX 1080 Ti	TITAN X	GTX 1080	GTX 980 Ti
CUDA cores	3,584	3,584	2,560	2,816
Streaming Multiprocessors	28	28	20	22
ROPs	88	96	64	96
Texture units	224	224	160	176
Base clock	1,480MHz	1,417MHz	1,607MHz	1,000MHz
Boost clock	1,582MHz	1,531MHz	1,733MHz	1,075MHz
VRAM (data rate)	11GB GDDR5X (11Gbps)	12GB GDDR5X (10Gbps)	8GB GDDR5X (10Gbps)	6GB GDDR5 (7Gbps)
Memory bus	352-bit	384-bit	256-bit	384-bit
Memory bandwidth	480GBps	480GBps	320GBps	336.5GBps
Fabrication process	TSMC 16nm	TSMC 16nm	TSMC 16nm	TSMC 28nm
Transistor count	12B	12B	7.2B	8B
Die size	471mm <sup>2</sup>	471mm <sup>2</sup>	314mm <sup>2</sup>	601mm <sup>2</sup>
TDP	250W	250W	180W	250W
Launch price	\$699	\$1,200	\$599 (\$699 Founders Edition)	\$649

same amount of power, the GTX 1080 Ti's cooler was quieter (2.5dB) and more effective.

The GTX 1080 Ti retains the GTX 1080's backplate design. Half of the backplate is removable, which provides additional airflow when multiple cards are yoked together in SLI.

### Fetching FETs

Speaking of power, NVIDIA paid special attention to the GTX 1080 Ti's power supply. The board is positively teeming with dualFETs, as NVIDIA used a pair for every one of the GTX 1080 Ti's seven power phases. Thanks to the extra dualFETs, NVIDIA was able to smooth out the GTX 1080 Ti's efficiency curve; at 150W, the card remains nearly 85% efficient, and it stays above 80% efficient at 200W, besting the GTX 1080 and GTX 980.

With its beefy power subsystem and refined cooler, the GTX 1080 Ti has an extra gear for times when it can rev its engine. NVIDIA reports that the card's clock can soar to 2GHz. Overclockers should find plenty of potential waiting for them to exploit.

### Pascal's Final Form

By most accounts, NVIDIA's Pascal rollout over the last year has gone according to plan. Power users holding out for a big discount on a top-shelf graphics card are in luck: The GeForce GTX 1080 Ti performs like a TITAN X but sells like a GTX 1080. ■

out of its VRAM. Tiled caching uses a tiled rendering approach combined with the GPU's L2 cache to reduce per pixel bandwidth. Lossless 4:1 and 8:1 delta color compression is another memory bandwidth booster. Although NVIDIA points out that real-world gains vary from game to game, the combination of tiled caching and delta color compression can theoretically boost the GTX 1080 Ti's memory bandwidth well beyond the 480GBps spec.

### Cooler Cooler

Aside from the Pascal architecture itself, the GTX 1080 Founders Edition distinguished itself with an attractive blower-style cooler, which blasts the card's heat directly out the back of the chassis. Although NVIDIA largely left the cooler's inner workings alone on the GTX 1080 Ti Founders Edition, the company did make a couple of changes to the rear bracket that yielded airflow gains. First and foremost, the DVI output, a mainstay on graphics cards

since the turn of the century, doesn't make the cut. Instead, the GTX 1080 Ti's rear bracket has three DisplayPort and one HDMI output. By eliminating the DVI port, NVIDIA was able to double the cooler's airflow.

Bell also points out another rear bracket modification likely to elude all but the most eagle-eyed enthusiasts. "There were changes made to the GTX 1080 Ti's cover to reduce the lip on the I/O bracket compared to the GTX 1080. If you look closely at the lip of your GTX 1080's bracket . . . you'll see that the GTX 1080 Ti's bracket is slightly thinner. Removing this wasted space on GTX 1080 Ti further enhances airflow."

In its internal testing, NVIDIA demonstrated the effects of these mods by testing the GTX 1080 and the GTX 1080 Ti with a 220W power draw. (We'll point out that in this scenario the GTX 1080 is actually operating beyond its 180W TDP, while the GTX 1080 Ti is running below its 250W TDP.) With both cards drawing the



NVIDIA appears to have squeezed every last drop of performance out of its Pascal architecture, making the GeForce GTX 1080 Ti a dynamite option for enthusiasts.

# Can We Build It?

## Alphacool Custom Hardline Cooling Tutorial, Part I

You don't have to be an avid fan of *CPU's Mad Reader Mods* to have noticed custom liquid cooling's—almost overnight—transition from soft silicone tubing to hardline. Although the performance characteristics for a hardline system shouldn't be any different compared to a flexible tubing-based cooling setup, the visual appeal of the former is undeniable. In all the time that we've been covering custom cooling, we have yet to actually build our own custom hard-tube loop. That changes with this two-part series designed walk you through the process of part picking, installing, bending, and filling a custom hardline liquid-cooling system from start to finish.

### But Why . . . Seriously?

Although most enthusiasts know the answer, we occasionally get asked why one would consider filling an expensive high-performance PC with a custom liquid-cooling setup. There are the thermal considerations; we all know that the clocks of a component like a processor or GPU can be pushed higher when they're running cool. But of course a closed-loop liquid cooler gets the job done without getting your hands wet. There are even semi-closed systems, such as Alphacool's expandable Eisbaer, which let you incorporate a liquid-cooled graphics card or two.

Although these "set and forget" systems will perform better than air coolers, their overall cooling capacity is hard limited. By going the custom route, you can install multiple radiators, massive reservoirs, and a half-dozen or more waterblocks. With a custom loop, you're only limited by how much you can fit into your enclosure, and some enterprising modders have no qualms about mounting cooling gear



Custom liquid-cooling systems using hardline tubing can make any PC look impressive.

outside the case. (External radiators used to be much more common back in the day, which is why many cases still come with rubber-grommated cooling ports in pairs built into their back panels.) Theoretically, the more liquid running through the system, the closer to ambient temperature you'll be able to get the components. However, there are diminishing returns when it comes to liquid cooling, and the degree of the overclock, as well as the thermal leakage properties of your CPU and GPU, also play major roles.

So, at the end of the day, it's mostly about the visual appeal. There is a performance angle, sure, but installing a sleek custom liquid-cooling system is arguably the most aesthetically striking thing we can do to make the PCs we love to work with lovely to look at, as well.

### Cooling Parts List

Whether you're using flexible or hardline acrylic/PETG (polyethylene

terephthalate glycol) tubing, all custom liquid-cooling systems typically require the same core components. These include a waterblock for the CPU and/or GPU(s), one or more radiators, a pump, fittings (two for each component in the loop), some kind of liquid coolant, and a reservoir.

CPU waterblocks need to be compatible with your motherboard socket mounting mechanisms. Our loop is for the CPU only, so we had Alphacool send us the Eisblock XPX. The system we're installing it in is running a Ryzen 7 1700X processor and an AORUS AX370-Gaming 5 motherboard, and happily, the Eisblock XPX was perfectly compatible with the AM4 socket.

Although a CPU block only needs to support the socket to properly fit in your system, full-cover GPU blocks need to be manufactured to the specifications of your particular graphics card model. Even minor variances in the position of VRM components and memory chips





There are a variety of ways to mount the large Alphacool Eisbecher D5 reservoir, and its capacity will chill even our overclocked Ryzen 7. Also, we're happy to report that that Alphacool's Eisblock XPX supports the AM4 socket right out of the box.

on the PCB, as well as the overall size and shape of the PCB, can result in block compatibility issues.

Reservoirs and radiators are bulky, and if you're working on an older case or one that was not designed with liquid cooling in mind, you may not be able to easily mount those items without significantly modifying the enclosure. There are lots of size options to consider when deciding on a radiator (or radiators), but the most important limiting factor is your case. Most cases built for liquid cooling support radiators that mount easily to 120mm fans, in 120 (one fan), 240 (two fans), 360 (three fans), and 480 (four fans) sizes. Fans and radiators sized in 140mm increments will tend to offer more cooling capacity or let you operate the fans at lower RPMs to get similar results. Because we're only cooling the processor, a single 240mm radiator, in the form of the NexXxos XT45, was our ideal choice. Also, don't forget to pair the radiator with appropriately sized fans. Fans designed to produce high static pressure are best suited for mounting to radiators. Alphacool sent us a pair of 120mm NB-eLoop Bionic fans.

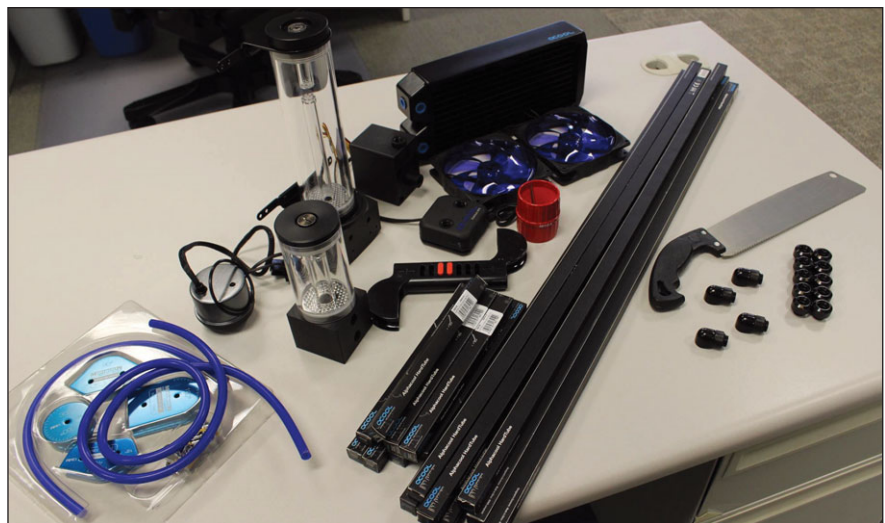
The reservoir we're using is the Alphacool Eisbecher D5, which mounts seamlessly to the Alphacool Eispumpe VPP755 pump. Keeping the reservoir and pump together as a single unit cuts down on the tubing we need to run, and the 250mm-tall clear reservoir holds plenty of liquid to keep our overclocked Ryzen 7 processor running cool. We also

got a 120/140mm bracket that lets us mount the Eisbecher to a radiator, or in our case, to a 120mm fan mount on the bottom of the case.

This tutorial will focus on building a hardline tubing system, and as a result, the fittings we acquired are designed to be used with acrylic or PETG tubing. If you want to build a flexible tubing-based system, we've had success with compression fittings from a number of vendors including XSPC, EK, and Swiftech.

The tubing we used is Alphacool's Eisrohr 13/10mm (ID 3/8-inch OD 1/2-inch) PETG HardTube, in 80cm sections. Based on our experience, it's best to order considerably more than you'll need, especially if you're just learning how to do it for the first time. As we went to press, the general consensus among modders and boutique PC builders seems to be that PETG is preferable to the more brittle and harder to bend acrylic. PETG is slightly more flexible, less prone to cracking, but may allow liquid to evaporate over time more than a comparable acrylic tube.

In addition to choosing the style of tubing, you also need to match the fittings to the ID (inner diameter) and OD (outer diameter) of your tubing.



Alphacool's Eddy Peters helpfully sent us a few extras he thought we'd need. He was right.

For our build, we got Alphacool's G1/4 (this refers to the 0.25-inch thread interface) Eiszapfen 13mm HardTube compression fittings, which are designed to work with the 13mm OD and 10mm ID PETG tubing we used. Although they seem superfluous, the set of four Alphacool rotatable Eiszapfen L-Connectors we got gave us a good deal of play when it came to sizing the tubing for the radiator. These little extras let us focus on making the pipes

After perusing the cooling parts list, you could be forgiven for thinking the difference between that process and installing a hardline tubing system is just a minor matter of bending the tubes. While that's true, bending and cutting hard tubes is an involved and somewhat complicated endeavor that requires more than a few pieces of specialized equipment, and (at least for us) a lot of trial and even more error. If our experience is any indication, you

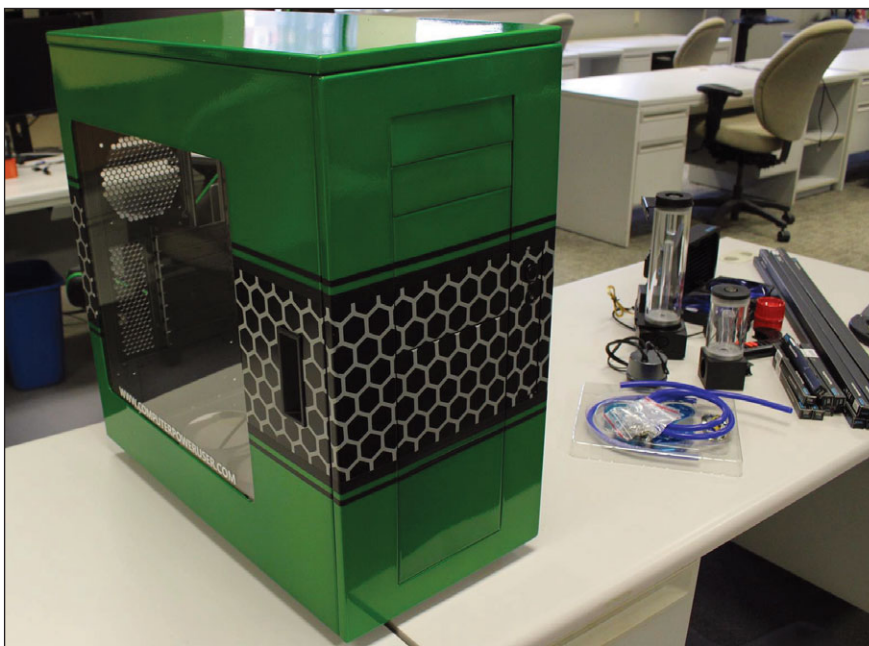
gun, gloves, a cutting tool, and a silicone insert. Our heat gun is a 1,200-watt model that has a high and low setting and that can be set upright for hands-free heating. Any pair of gloves that will insulate your hands from the exhaust of the heat gun and let you handle the heated plastic without burning your fingers will work. To cut the tube to size, we ordered the Alphacool pit saw, which has an impressive-looking 35cm blade.

The silicone insert should be measured to fit fairly snugly inside the tubes to ensure that the tube doesn't collapse or kink when bending. The 100cm Alphacool Silicon Bending Insert we got is sized for the 10mm ID of the tubes we're working with. If the insert is a little too snug, try sanding it down slightly with a piece of sandpaper. We also recommend using a little bit of olive oil to lubricate the insert for easy removal once the bend is complete. According to Richard "DarthBeavis" Surroz, who is no stranger to PETG bending, olive oil is ideal because it doesn't burn as the pipe is heated and it cleans up easily. Another tip we got from DB is to use an eyeliner pencil to make the marks on the pipe so you know the portion to heat for each bend. Once bent, the marks can be wiped away.

Once you've bent the pipes and cut them to the appropriate lengths, it's a good idea to use a deburring tool on the inner and outer edges of each piece that you'll be slotting into a fitting. This ensures a snug leak-free fit every time. We used the double-sided Alphacool Acrylic Tubing Pipe Reamer, which features blades for deburring the inside and outside of the pipe on either end.

### Slow Down At The Bends

When it comes to actually bending and shaping the heated tube, there are several tools that can help you get solid results. Some experienced builders prefer to bend by hand. Next month, as we conclude our project, we'll try our hand at a little bit of everything and put the finishing touches on our first custom hardline tubing project. ■



We've got a tough job ahead of us as we try to make the interior of the CaseLabs Merlin SM8 as impressive as its BSMODS-designed paint job.

look straight and giving them a snug fit without having to resort to re-bending the tube with our heat gun.

For this build, space shouldn't be a problem for us; we're using CaseLabs' cavernous Merlin SM8, which has been given a stunning *CPU*-themed update designed by our friends at BSMODS. (Thanks again, guys!)

### Tools Of The Trade

When installing a flexible tubing cooling system, the only required equipment is a hearty pair of scissors, a funnel, and some paper towels.

won't get it right the first time, and maybe not even the second time. But the end result will be worth the piles of hideously misshapen plastic littering your workspace. Spoiler alert for Part II of this article (which will appear in our May issue): We have a newfound respect for the skill that goes into the hardline tubing designs that grace the pages of this magazine every month.

### Must-Haves

There are a handful of items that are absolutely required for bending PETG or acrylic tubes, and they include a heat



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[www.booksmania.net](http://www.booksmania.net)

# Temp Workers

## Beat The Heat With A New CPU Cooler

Of all the rites of passage an initiate must complete before being accepted into our tribe of enthusiasts, overclocking a CPU is among the most venerated. For first-timers, the idea of pushing the processor beyond its stock clock can be a daunting task, but we don't send anyone into the wild to slay this beast without a proper weapon. Nothing instills confidence quite like bringing a reliable and powerful CPU cooler to the fight. Whether you choose to use a heatsink and fan or build an elaborate custom watercooling loop, the right setup is essential to keep your cranked-up CPU running within its thermal envelope.

Now, we understand that overclocking isn't for everyone or every system. Virtually every processor needs some form of cooling, though, and we think you can do better than the meager heatsink and whiny fan packaged with most retail boxed processors. Aftermarket coolers do more than make world record overlocks possible, after all; even knocking a few decibels off your rig's noise output is enough to justify an upgrade. We've collected an 18-pack of coolers ranging from budget-friendly to bombastic. There really is something for everyone.

### Ryzen Rendezvous

At the beginning of March, AMD released its hotly anticipated Ryzen 7 processors to enthusiasts eager to put the company's Zen architecture on the test track. And if the rollout continues according to plan, Ryzen 5 chips should be available shortly after you read this.

These new processors use a new socket—AM4—and that means some coolers may not be compatible with Ryzen CPUs. Several manufacturers have already started including AM4 adapters with their coolers, and others make them available by request and/or as an optional purchase. If you're rolling with Ryzen, double-check that your chosen cooler is compatible. Contact the manufacturer if necessary. Their coolers might be updated even if their websites aren't.

### Nice Threads

Closed-loop liquid coolers aren't as closed as they used to be. Today, lots of AIO (all-in-one) units have G1/4 threads, and some also include tubing with quick-disconnects. When you decide to step up to a more substantial loop, these coolers can stick around, stretching your enthusiast dollar further. Other amenities such as LED-lit waterblocks and prepackaged coolant dyes let you put a little custom in your closed-loop cooler.



## Corsair Hydro Series H110i

\$139.99

[www.corsair.com](http://www.corsair.com)

**Why You'll Dig It:** Corsair's Hydro Series H110i is a beast with brains. First, a 280mm radiator provides a ton of surface area for exhausting heat, and the pair of SP140L PWM fans produce insanely high static pressure (3.99mm-H<sub>2</sub>O, in case you were wondering). Together the radiator and fans combine to rapidly remove heat from the coolant as it courses through this closed-loop cooler. The H110i's pump/waterblock combo unit does more than absorb heat from the CPU and keep the loop's coolant flowing. Equipped with Corsair Link, plug the H110i's Corsair Link cable into a USB header on your motherboard and download the free software from Corsair's website. Using the software, you can keep an eye on the temperature of both the coolant and your CPU, change the LEDs on the block unit, and set the LEDs to change color according to temperature.

**Who Should Apply:** Intrepid overclockers who want to know exactly how their handiwork is affecting CPU temps.

Radiator (actual width): 280 (12.7 inches/322mm)

Fans: 2 x 140mm (Up to 2,100rpm)

Rated noise level: Up to 43db(A)



## Alphacool Eisbaer 360

\$147.05

[www.alphacool.com](http://www.alphacool.com)

**Why You'll Dig It:** The Eisbaer 360 is an AIO with lots of room to grow. When the time comes to expand your loop, its radiator and pump/waterblock combo unit have G1/4 threads, making them compatible with the vast majority of custom liquid-cooling hardware. The Eisbaer is also equipped with Alphacool's quick-disconnect system, which lets you combine it with one of Alphacool's Eiswolf GPU AIOs in a matter of seconds. Of course, the Eisbaer is an outstanding cooler even if you have no intention of going beyond watercooling your CPU. It's virtually overflowing with exceptional Alphacool components, including a 360mm NexXos radiator, Eiswind fans, and a windowed pump/block combo unit that lets you take a peek at the action. There's a fill port atop the combo unit, too, so maintenance is a snap.

**Who Should Apply:** As long as your case is big enough to house this beast, the Eisbaer 360's gigantic rad will make any overclocker happy.

Radiator (actual width): 360 (15.7 inches/400mm)

Fans: 3 x 120mm (550-1,700rpm)

Rated noise level: Up to 29db(A)



## Corsair Hydro Series H100i v2

\$129.99

[www.corsair.com](http://www.corsair.com)

**Why You'll Dig It:** Inside and out, the Hydro Series H100i v2 exhibits the careful thought Corsair puts into its AIO CPU coolers. The H100i v2's 240mm radiator should fit into virtually any case (aside from some obvious exclusions, like certain SFF and HTPC cases), making it an ideal choice for a variety of systems and builds. Like the Hydro Series H110i, Corsair goes all in on static pressure. Unlike some closed-loop liquid coolers, which could use any old fan(s), the H100i v2 has a pair of SP120L fans. These blowers are built to be bolted to rads, which the H100i v2's rated static pressure of 4.65mm-H<sub>2</sub>O clearly shows; there aren't too many fans capable of pushing air through a radiator's fins as forcefully as the SP120Ls. And of course, Corsair Link is as useful as ever on the H100i v2. Download it for free to keep tabs on temps, control the LEDs on the H100i v2's pump/block combo unit, and more.

**Who Should Apply:** If the Hydro Series H110i is slightly too big for your case, the H100i v2 should do the trick.

Radiator (actual width): 240 (10.9 inches/276mm)

Fans: 2 x 120mm (Up to 2,435rpm)

Rated noise level: Up to 37.7db(A)



## be quiet! Dark Rock Pro 3

\$89.99

[www.bequiet.com](http://www.bequiet.com)

**Why You'll Dig It:** Those Germans and their engineering—be quiet! is to cases, coolers, and power supplies what Volkswagen is to automobiles, and that's a good thing. With the Dark Rock Pro 3, be quiet! sets out to prove that air coolers are certainly capable of hanging with closed-loop liquid coolers. A monolithic mass of seven copper heatpipes, 90 aluminum fins, and a copper base, the Dark Rock Pro 3's heatsink means business, and the dark nickel plating is simply stunning. A 135mm SilentWings fan is nestled between the Dark Rock Pro 3's twin towers of fins, and a 120mm SilentWings fan clips to the front. True to their name, the fans don't exceed 26.1 decibels, even when running full throttle.

**Who Should Apply:** Air cooling aficionados who want to put a tiny tornado inside their chassis.

Dimensions (HxWxD): 6.4 x 5.4 x 5.9 inches

Fans: 1 x 135mm (max 1,400rpm), 1 x 120mm (max 1,700rpm)

Rated noise level: Up to 26.1dB(A)





## Swiftech H240 X2 Prestige

\$199.99

[www.swiftech.com](http://www.swiftech.com)

**Why You'll Dig It:** Swiftech has long been at the forefront of CPU cooling, particularly watercooling. Enthusiasts intent on building custom loops regularly use individual Swiftech components (waterblocks, pumps, etc.); with the X2 family of AIO coolers, Swiftech does most of the work for you. The H240 X Prestige's centerpiece is an Apogee XL waterblock, which has a chrome-plated copper base and a clear acrylic housing. The latter is particularly helpful for showing off the custom-tinted coolant you create by mixing in the included Mayhems dyes. (Swiftech gives you vials of red, green, and blue.) Swiftech gives this cooler a couple of nice upgrades to earn its "Prestige" billing: Lok Seal black chrome compression fittings and a pair of Noiseblocker NB-eLoop 240mm fans.

**Who Should Apply:** Mad scientists who want to brew their own coolant inside the loop of a powerful AIO liquid CPU cooler.

Radiator (actual width): 280 (11.5 inches/293mm)

Fans: 2 x 140mm (500-1,800rpm)

Rated noise level: Up to 36.4db(A)



## Phanteks PH-TC14S

\$49.99

[phanteks.com](http://phanteks.com)

**Why You'll Dig It:** Phanteks' PH-TC14S sets out to prove that thin is in. Built to live in harmony with your DRAM, the PH-TC14S is only 2.9 inches deep, which should keep it clear from any motherboard's DIMM slots. The copper base and six 6mm heatpipes are nickel-plated, and the heatsink fins receive an application of Phanteks' patented P.A.T.S. (Physical Antioxidant Thermal Spraying). Although this cooler only has a single 140mm fan, the PH-F140HP is a force to be reckoned with. Thanks to its static pressure rating of 1.64mm-H<sub>2</sub>O, this fan has no trouble blowing air through the PH-TC14S' dense array of fins. As the company does with all of its coolers, Phanteks bestows the PH-TC14S with an impressive five-year warranty.

**Who Should Apply:** Builders with skyscraping memory modules who don't want to play the will-they-or-won't-they clearance game.

Dimensions (HxWxD): 6.3 x 5.6 x 2.9 inches

Fans: 1 x 140mm (600-1,300rpm)

Rated noise level: Up to 19 dB(A)



## ENERMAX ETS-N31

\$19.99

[www.enermax.com](http://www.enermax.com)

**Why You'll Dig It:** For the cost of dinner for two at Applebee's, ENERMAX's ETS-N31 includes all of the company's most recent cooling innovations (such as Vortex Generator Flow, Vacuum Effect, and Heatpipe Direct Touch). We know how we'd choose to spend our hard-earned twenty. Capable of cooling processors with a rated TDP up to 130W, the ETS-N31 is a great option for midrange systems. And thanks to the ETS-N31's asymmetric heatpipe design, it shouldn't hang over your motherboard's DIMM slots, a common problem with air coolers. To secure the ETS-N31's fan to its heatsink, ENERMAX includes a 1-clip fan bracket, which is a lot easier to use than the oversized paper clips a lot of manufacturers use to do the same job.

**Who Should Apply:** With its AM4 socket compatibility, Ryzen 5 buyers should put this cooler on their radar when the CPUs launch in April.

Dimensions (HxWxD): 4.9 x 3.7 x 3.1 inches

Fans: 1 x 92mm (800-2,000rpm)

Rated noise level: Up to 24.5db(A)



## GIGABYTE XTC700

\$89.99

[www.gigabyte.us](http://www.gigabyte.us)

**Why You'll Dig It:** Big and bright, the XTC700 knows how to keep a CPU cool and look good doing it. Not content with 6mm or even 8mm heatpipes, this cooler's heatsink has three meaty 10mm pipes, and they make direct contact with the CPU's integrated heat spreader. A pair of 120mm PWM fans bookend the XTC700's heatsink, and these aren't your garden-variety propellers. They have a double ball bearing design, which gives them a life span of more than five years, according to GIGABYTE, and their specially designed fan blades focus airflow through the heatsink. GIGABYTE tops off the XTC700 with an LED-lit cover that is highly customizable. In addition to giving you 16.8 million colors to choose from, the XTC700 has a few lighting effects, as well. AMD Ryzen buyers should know that GIGABYTE is readying an AM4 adapter for the XTC700; it's expected to be available mid-April.

**Who Should Apply:** GIGABYTE loyalists should be first in line, but the XTC700 is a dynamite air cooler for any enthusiast.

Dimensions (HxWxD): 6.7 x 5.5 x 4.4 inches

Fans: 2 x 120mm (500-1,700rpm)

Rated noise level: 12-31dB(A)





## LEPA NEOllusion

\$59.99

[www.lepatek.com](http://www.lepatek.com)

**Why You'll Dig It:** Today the question isn't "What components have LED lighting?" but rather "What components don't?" LED lights are everywhere, including on solid-state drives and graphics cards. If you want to extend LED lighting to every corner of your computer, LEPA's NEOllusion is an ideal air cooler for the job. LEPA also gives you a great deal of command over the NEOllusion's LEDs by including a capable remote control. The remote has a palette of 16 colors, as well as a pair of lighting effects, so matching the NEOllusion to your other components' lights ought to be an easy job. Aside from the sparkle, there's plenty of substance, here, too. In addition to the usual patented technologies (Vortex Generator Flow and Heatpipe Direct Touch) the NEOllusion's fan features dual convex blades that focus airflow through the heatsink much more than traditional fan blades.

**Who Should Apply:** Obviously, if you want to light up your rig, you need this cooler.

Dimensions (HxWxD): 6.4 x 5 x 2.6 inches

Fans: 1 x 120mm (600-1,800rpm)

Rated noise level: 17-33dB(A) (14-19dB(A) with fan adapter)



## Zalman CNPS8X Optima

\$24.99

[www.zalman.com](http://www.zalman.com)

**Why You'll Dig It:** Since its founding, Zalman's mission has been to develop PC cooling options that blow away heat without blowing out your eardrums. After almost two decades, you'd better believe that the company knows how to make a solid CPU cooler. The CNPS8X Optima will only set you back 25 bucks, but you wouldn't know it based on all of its features. Zalman's engineers paid special attention to the CNPS8X Optima's heatsink fins, precisely sculpting them to maximize airflow. Of course, the 100mm Shark Fin Blade Fan does plenty of work, too; the blades' shape slashes air turbulence. An included packet of ZM-STG2M thermal grease is the icing on this extremely tempting cake.

**Who Should Apply:** Builders looking for an effective CPU cooler that delivers terrific performance at a sensational price.

Dimensions (HxWxD): 5.8 x 4.3 x 3.2 inches

Fans: 1 x 100mm (1,200-2,100rpm)

Rated noise level: 18.2 to 30dB(A)



## Phanteks PH-TC14PE

\$99.99

phanteks.com

**Why You'll Dig It:** If your answer to the question "How big should a good air cooler be?" is "bigger," then allow us to present the Phanteks PH-TC14PE. This menacing cooler measures a towering 6.7 inches high and 6.3 inches from front to back, but what's between those gargantuan dimensions is what really matters. Phanteks infuses the PH-TC14PE's heatsink with the company's P.A.T.S (Physical Antioxidant Thermal Spraying) and C.P.S.C treatments, which improve heat dissipation and transfer. An array of five copper heatpipes and two piles of aluminum fins absorbs heat, and a pair of PH-F140TS fans take care of the rest. Phanteks also includes its PH-NDC thermal compound with the PH-TC14PE.

**Who Should Apply:** Power users interested in buying a massive air cooler first and worrying about the rest later.

Dimensions (HxWxD): 6.7 x 5.5 x 6.3 inches

Fans: 2 x 140mm (600-1,300rpm)

Rated noise level: Up to 19 dB(A)



## ARCTIC Freezer 33 Plus

\$49.99

www.arctic.ac

**Why You'll Dig It:** ARCTIC's Freezer 33 Plus packs a lot of cooling into a relatively small footprint. Despite having a 120mm fan clipped to either side of the Freezer 33 Plus' heatsink, this cooler shouldn't invade the airspace over your motherboard's DIMM slots. Go ahead and hang on to your high-end memory modules that have towering heat spreaders. The heatsink itself consists of four 6mm heatpipes that make direct contact with the CPU's heat spreader, plus a stack of 49 0.5mm-thick aluminum fins. ARCTIC engineered the Freezer 33 Plus to put a lot of the work in the heatsink's hands. The PWM fans won't kick on until they detect a 40% load, effectively making the cooler silent when your system's CPU is untaxed.

**Who Should Apply:** Enthusiasts who need to fit a powerful cooler into a tight space.

Dimensions (HxWxD): 5.9 x 4.8 x 4 inches

Fans: 2 x 120mm (0-1,350rpm)

Rated noise level: Up to 0.3 Sone





## Alphacool Eiswand

\$367.64

[www.alphacool.com](http://www.alphacool.com)

**Why You'll Dig It:** Think of Alphacool's Eiswand as an AIO with some assembly required. Once it is assembled, though, look out. Obviously not designed to fit inside a case (hint: now's your chance to finally use your case's predrilled tubing holes), Alphacool takes advantage of having no size restrictions to build a radiator housing of massive proportions. Lurking inside is a 360mm NexXos XT45 radiator, six—count 'em, six—Eiswind fans, and a double helping of Alphacool's DC-LT 2600 ultra-low noise ceramic pump. Cut the tubing, hook up the Eiswand's tower of power to the included NexXos XP<sup>3</sup> Light waterblock, fill it up with Alphacool CKC coolant, and reap the rewards.

**Who Should Apply:** Power users who plan on pushing their CPU to new heights.

Radiator (actual width): 360 (20.1 inches/535mm)

Fans: 6 x 120mm (Up to 1,100rpm)

Rated noise level: Up to 29db(A)



## Swiftech H220 X2

\$139.95

[www.swiftech.com](http://www.swiftech.com)

**Why You'll Dig It:** Plenty of closed-loop liquid coolers keep their coolant hidden behind opaque tubing. Swiftech demands that you show it off, supplying the H220 X2 with everything you need to make your own visual statement. In addition to using clear Mayhems tubing, Swiftech adds a clear acrylic reservoir and then puts it front and center. Squeeze in a few (or several) drops from the set of included Mayhems dyes (red, green, and blue) to match the H220 X2 to the rest of your build's color scheme. (We'd recommend testing dye combinations outside the loop before you commit to tinting your coolant.) Swiftech's Apogee XL2 waterblock has a clear acrylic housing and addressable RGB LEDs, which further accentuate your custom coolant. Bristling with other excellent components, such as a pair of 120mm Swiftech Helix fans, a PWM pump, and a 240mm radiator, the H220 X2 not only looks great but also works hard. Thanks to its G1/4 threads, expanding your AIO loop to a larger custom setup is a breeze.

**Who Should Apply:** Power users who want an all-in-one cooler that doesn't look like every other closed-loop cooler on the market.

Radiator (actual width): 240 (10 inches/254mm)

Fans: 2 x 120mm (800-1,800rpm)

Rated noise level: 16-33db(A)



## ARCTIC Freezer 12

\$39.99

[www.arctic.ac](http://www.arctic.ac)

**Why You'll Dig It:** Following up on its Freezer i11 family, ARCTIC has released the Freezer 12, a compact cooler capable of holding high-end processors in check. (The Freezer 12 is compatible with Intel LGA 2011-3 and AMD AM4 sockets, among others.) ARCTIC's focus on acoustics is obvious, as the Freezer 12 has several features designed to operate as quietly as possible. The 92mm fan is equipped with rubber mounts that keep vibration to a minimum, and the Freezer 12 has the same passive cooling mode as the Freezer 33 series. If the Freezer 12's heatsink can handle a particular thermal load by itself, the fan remains dormant and, more importantly, silent. ARCTIC also includes a syringe of its high-performance MX-4 thermal paste.

**Who Should Apply:** Power users interested in a CPU cooler that tackles heat without making a ruckus.

Dimensions (HxWxD): 5.1 x 4.3 x 3.5 inches

Fans: 1 x 92mm (0-2,000rpm)

Rated noise level: Up to 0.3 Sone



## Zalman CNPS2X

\$26.99

[www.zalman.com](http://www.zalman.com)

**Why You'll Dig It:** Zalman's diminutive CNPS2X might keep a low profile, but it makes its presence known in other ways. Shorter than a lot of memory modules, vertical clearance won't be a problem with the CNPS2X. Because of its donut shape, you'll only find a single heatpipe on the CNPS2X, but Zalman makes it count. Using "S" bending technology, Zalman wraps the heatpipe around the entire circumference of the radially oriented heatsink fins and then shoots it through the heatsink's base, where it makes direct contact with your CPU's heat spreader. Topping out at 22.7dB(A), the CNPS2X keeps quiet while it keeps your CPU cool.

**Who Should Apply:** The CNPS2X is tailor-made for SFF systems and HTPCs, but anyone using a Mini-ITX motherboard should give this CPU cooler a look.

Dimensions (HxWxD): 1.1 x 3.3 x 3.3 inches

Fans: 1 x 80mm (1,500-2,600rpm)

Rated noise level: 17.4-22.7dB(A)





## be quiet! Pure Rock

\$34.90

[www.bequiet.com](http://www.bequiet.com)

**Why You'll Dig It:** The Pure Rock certainly lives up to its creator's moniker. Even when the cooler's 120mm fan is swirling at full strength, the Pure Rock's maximum noise output doesn't exceed 25.4dB(A); as far as fans go, that's being pretty quiet. The secret to the Pure Rock's small sonic footprint is its SilentWings PWM fan. be quiet! shapes the nine fan blades to minimize the turbulence that leads to noise. Obviously, the Pure Rock has more going for it than a fancy fan. A quartet of 6mm copper heatpipes runs through the Pure Rock's base and aluminum fins. At the top of the cooler, the heatpipes are capped with aluminum to match the top cover. For under 35 bucks, the Pure Rock can handle CPUs up to 150W TDP.

**Who Should Apply:** Power users who want an affordable CPU cooler that knows how to stay quiet.

Dimensions (HxWxD): 6.1 x 4.8 x 3.4 inches

Fans: 1 x 120mm (Up to 1,500rpm)

Rated noise level: Up to 26.8dB(A)



## MSI CORE FROZR L

\$54.99

[us.msi.com](http://us.msi.com)

**Why You'll Dig It:** Better known for its cutting-edge motherboards and graphics cards, MSI's product portfolio includes everything from gaming mice to high-end PCs. It's no surprise that the company dabbles in CPU cooling, as well. MSI has put a lot of R&D into the coolers it attaches to its graphics cards, so it only makes sense that the Core Frozr L shares some of that DNA. Specifically, the cooler relies on one of MSI's patented TORX fans to keep air moving. A TORX fan includes what MSI calls dispersion fan blades, which have a steeper curve for more airflow. And if you want to add a little pull to your push, you can easily clip a second fan (sold separately, but the mounting hardware is included with the cooler) to the Core Frozr L's back.

**Who Should Apply:** MSI loyalists who are well acquainted with MSI's workmanship and want to extend it with additional components.

Dimensions (HxWxD): 6.1 x 5.5 x 3.3 inches

Fans: 1 x 120mm (500-1,800rpm)

Rated noise level: 17.2 to 33.6dB(A)



Closed-loop	MSRP	Radiator	Fans	Rated Noise Level	Intel Socket Compatibility	AMD Socket Compatibility (*via adapter)	Warranty
Alphacool Eiswand	\$367.64	360mm	6 120mm	Up to 29dB(A)	Intel LGA 2011-3/2011/1366/115X/775	FM1, FM2 (+), AM2 (+), AM3 (+), AM4*	2 years
Swiftech H240 X2 Prestige	\$199.95	280mm	2 140mm	Up to 36.4dB(A)	LGA 2011-3/2011/115X	FM1, FM2 (+), AM2 (+), AM3 (+), AM4, 939	3 years
Alphacool Eisbaer 360	\$147.05	360mm	3 120mm	Up to 29dB(A)	Intel LGA 2011-3/2011/1366/115X/775	FM1, FM2 (+), AM2 (+), AM3 (+), AM4*	2 years
Corsair Hydro Series H110i	\$139.99	280mm	2 140mm	Up to 43dB(A)	LGA 2011-3/2011/1366/115X	FM1, FM2 (+), AM2 (+), AM3 (+), AM4	5 years
Swiftech H220 X2	\$139.95	240mm	2 120mm	16 to 33dB(A)	Intel LGA 2011-3/2011/115X	FM1, FM2 (+), AM2 (+), AM3 (+), AM4, 939	3 years
Corsair Hydro Series H100i v2	\$129.99	240mm	2 120mm	Up to 37.7dB(A)	Intel LGA 2011-3/2011/1366/115X	FM1, FM2 (+), AM2 (+), AM3 (+)	5 years
Air Cooler	MSRP	Dimensions (inches; HxWxD)	Fans	Rated Noise Level	Intel Socket Compatibility	AMD Socket Compatibility (*via adapter)	Warranty
Phanteks PH-TC14PE	\$99.99	6.7 x 5.5 x 6.3	2 140mm	Up to 19dB(A)	LGA 2011-3/2011/1366/115X/775	FM1, FM2(+), AM2(+), AM3(+)	5 years
be quiet! Dark Rock Pro 3	\$89.99	6.4 x 5.4 x 5.9	1 120mm, 1 135mm	Up to 26.1dB(A)	LGA 2011-3/2011/1366/115X/775	FM1, FM2(+), AM2(+), AM3(+), AM4*, 754/939/940	3 years
GIGABYTE XTC700	\$89.99	6.7 x 5.5 x 4.4	2 120mm	12 to 31dB(A)	LGA 2011-3/2011/1366/115X/775	FM1, FM2(+), AM2(+), AM3(+), AM4*, 754/939	3 years
LEPA NEOllusion	\$59.99	6.4 x 5 x 2.6	1 120mm	17 to 33dB(A)	LGA 2011-3/2011/1366/115X/775	FM1, FM2(+), AM2(+), AM3(+), AM4*	1 year
MSI Core Frozr L	\$54.99	6.1 x 5.5 x 3.3	1 120mm	17.2 to 33.6dB(A)	LGA 2011-3/2011/1366/115X/775	FM1, FM2, AM2(+), AM3(+), AM4	3 years
Arctic Freezer 33 Plus	\$49.99	5.9 x 4.8 x 4	2 120mm	Up to 0.3 Sone	LGA 2011-3/2011/115X	AM4	6 years
Phanteks PH-TC14S	\$49.99	6.2 x 5.6 x 2.9	1 140mm	Up to 19dB(A)	LGA 2011-3/2011/1366/115X/775	FM1, FM2, AM2(+), AM3(+)	5 years
Arctic Freezer 12	\$39.99	5.1 x 4.3 x 3.5	1 92mm	Up to 0.3 Sone	LGA 2011-3/2011/115X	AM4	6 years
be quiet! Pure Rock	\$34.90	6.1 x 4.8 x 3.4	1 120mm	Up to 26.8dB(A)	LGA 2011-3/2011/1366/115X/775	FM1, FM2(+), AM2(+), AM3(+), AM4, 754/939/940	3 years
Zalman CNPS2X	\$26.99	1.1 x 3.3 x 3.3	1 80mm	17.4 to 22.7dB(A)	LGA 115X/775	FM1, FM2, AM2(+), AM3(+), AM4*	1 year
Zalman CNPS8X Optima	\$24.99	5.8 x 4.3 x 3.2	1 100mm	18.2 to 30dB(A)	LGA 115X/775	FM1, FM2, AM2(+), AM3(+), AM4	1 year
ENERMAX ETS-N31	\$19.99	4.9 x 3.7 x 3.1	1 92mm	Up to 24.5dB(A)	LGA 1366/115X/775	FM1, FM2 (+), AM2 (+), AM3 (+), AM4	1 year



# Spring Data Cleaning

## Tips, Tricks & Apps To Take Back Your Storage

Immaculate rigs are one of the telltale signs of serious enthusiasts, and they're easy to spot. You all know the hallmarks: case panels free of pizza-laced fingerprints, power and data cables properly wrangled and tucked out of sight, LED lights that match the rest of the system's color scheme, and more. We take pride in our PCs and want them to look their best.

Appearances can be deceiving, though, and we aren't talking about the horrors we hide behind a solid right-side panel. As we fly from website to website, download and install dozens of programs, and shuffle media files to and from our home server, digital garbage builds up. Like its real-world counterpart, the trash collecting on our machines rarely starts as a serious problem. At first, you might not even notice it; if an uninstalled program leaves behind remnants that don't affect overall performance, how likely are you to hunt down orphaned files?

If you're not careful, you can turn into a full-blown data hoarder. You start telling concerned friends and family that your bloated web browser cache is actually a good thing, "because I might want to make a return trip to freshneildegassetysonmemes.com, and shaving half a second off the load time is something I need in my life." Instead of eradicating dubiously useful apps that drag down boot times, you simply stop shutting down your PC. Rather than shredding massive files and folders you never use, you buy another hard drive. ("They're cheap, anyway.")

We don't like seeing all this sludge polluting system drives and ruining lives. It's time to break the cycle and return your PC to its original condition (or as close as possible, anyway). No, meticulously organized files and folders aren't as sexy as a fully modded PC, but



what's inside counts, too. You didn't spend thousands of dollars assembling a dream team of components only to have them play like the Washington Generals, so let's draw up battle plans to fight back.

### The Nuclear Option

As tempting as it is to issue the blanket statement, "every PC, no matter how far gone, can be salvaged," we're not averse to cutting our losses and throwing in the towel when a fresh start is the best choice. Rather than track down every last bit of detritus, a clean Windows installation wipes away everything in one step.

Obviously, we don't recommend breaking out your installation media and pressing the self-destruct button without a second thought. If your computer is anything like ours, there's plenty of good that you don't want to toss out alongside the bad. Sure, you'll want to back up photos, important documents, and so

forth, but you should be mindful of other important items that could inadvertently end up flushed down the drain—permanently, in some cases—during a clean install.

To start, find your keys. That means product keys. It's a lot easier to pack up and move apps than it was years ago, but a program that requires a key will usually want it again as soon as you reinstall it. For that matter, perhaps you've been less than vigilant with your Windows key. In either situation, you need a way to recover those strings of numbers and letters.

Thankfully, there's no shortage of free programs that will recover AWOL keys. One of our favorites is Magical Jelly Bean KeyFinder. In addition to not costing a dime, MJBK is lightweight and easy to use. It will recapture keys for about 300 software titles in addition to Windows. Belarc Advisor works well, too, and provides lots of additional

system info. Try these before using a paid key finder, which can suss out keys for thousands of programs.

Although we ultimately want to return obese web browsers to a slimmer figure, you may want to bring along some of your browser's weight if your plan is to wipe your drives and start from scratch. If you already sign in to your browser, then you're halfway home, thanks to syncing. (All major browsers can do it to varying degrees.)

If you'd rather roll up your sleeves and do it yourself, or if you don't want your browser's sync feature to take everything with it, you might be able to hand-pick things depending on what browser you use. For example, if you dig in to Chrome's flags, you can manually export the usernames and passwords you've saved in the browser. Open Chrome, type **chrome://flags** in the address bar, press ENTER, and scroll down to Password Import and Export. Select Enabled and restart Chrome. Next, type **chrome://settings/passwords** and press ENTER. Chrome should display its stored login credentials. Click Export, enter your Windows password, and save the .CSV file. On your clean PC, enable the export/import flag in Chrome, open the passwords window, and click Import to transfer the credentials.

We'll assume you know how to find and back up your personal files, but gathering your device drivers before blowing up your current Windows installation might save you time and a headache or two. Although the majority of drivers are available online and Windows itself does a decent job finding drivers for most hardware, there are free utilities that can round up your drivers and have them ready for a clean install. Available at open-source megasite SourceForge, DriverBackup! scans your system for drivers and then packages them together. After you've downloaded and extracted the ZIP folder (yes, DriverBackup! is portable, too), open the program, select the Backup mode, review your drivers,

and decide which ones will survive your nuke-and-pave operation. Uncheck the drivers you don't want and then click Start Backup. Relaunch DriverBackup! after the clean installation and switch to Restore mode. Point the program to the backup file you created, click Restore, and let DriverBackup! work its magic.

You should also double-check licenses and DRM on any software and music/movies you've purchased. As an easy

than not, a targeted approach will take care of these problems much more quickly.

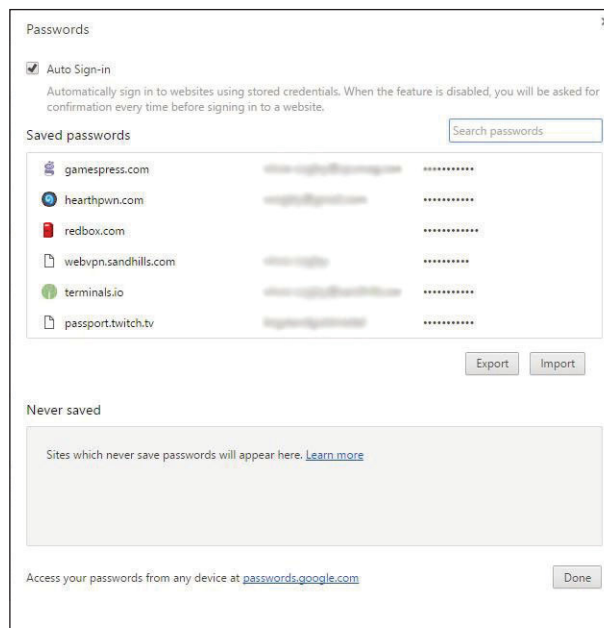
## Call A Cleaner

Most power users prefer a hands-on approach to computing, favoring their own skills over software wizards and one-click performance optimizers. However, this attitude relates more to the "fun stuff," such as overclocking, case modding, and so forth, rather than the tedium involved with picking through the Registry. No one signs up to be a PC enthusiast because taking out the trash is an exhilarating experience.

For cleaning the crap on a system, few programs are as good as the one that was originally called "Crap Cleaner." Now with a more dignified name, Piriform's CCleaner ([www.piriform.com/ccleaner](http://www.piriform.com/ccleaner)) is still going strong 13 years after its debut, and it's usually the first program we turn to if we need to dump lots of useless files in a little amount of time. Piriform updates CCleaner on a monthly basis, so it continues to be more efficient. As a freemium app, you can pay for additional features (such as the \$24.99 Professional version's real-time monitoring), but we've found CCleaner Free capable of handling most cleaning jobs.

Once you launch CCleaner, the program gets right down to business, presenting you with all of its cleaning tools for Windows and other supported apps on your system. For Windows cleaning, CCleaner targets Edge and Internet Explorer browsers, Windows Explorer, and Windows system files. Its primary targets are things like your web browser's cache and temporary files, memory dumps, and log files, but the program can shred lots of other things, as well.

Decide what you want CCleaner to scan for and fix by checking and unchecking the relevant boxes, then click Analyze. CCleaner goes to work and shows you an itemized report of its kill



Even if you plan on blowing up your Windows installation and performing a clean installation, some things should survive. Google Chrome can export login credentials to a .CSV file, which you can import on the clean OS.

example, Apple limits the number of devices that are authorized to play content bought from iTunes. Commercial software licenses are a similar animal, usually limiting the installations you can perform to a specific number of machines. We recommend de-authorizing any program that imposes such limits before the big reset.

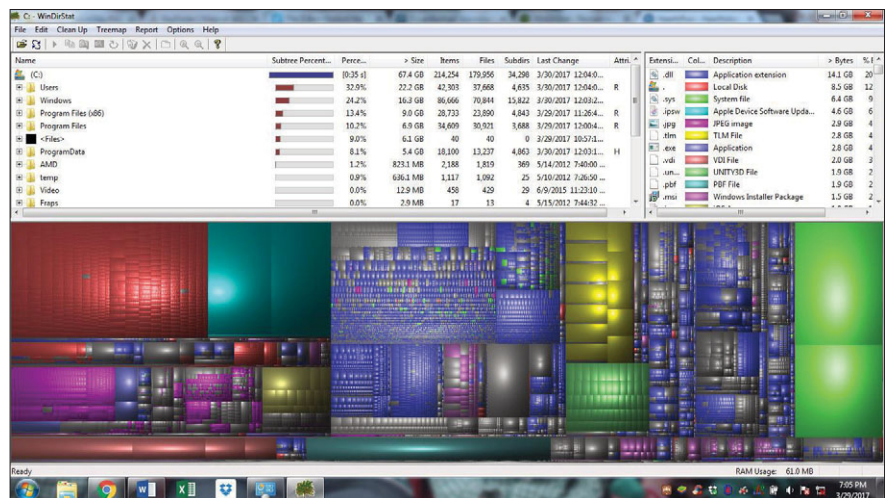
A clean installation is virtually guaranteed to purge unwanted files and clear away any gremlins causing system slowdowns and other issues, but it can be a time-consuming process, especially for enthusiasts whose systems are laden with apps, games, and other data. More often



list and how much space you'll reclaim by letting the program eradicate the tagged files. Click Run Cleaner, and CCleaner takes care of the rest. Its built-in Registry cleaner functions the same way. CCleaner offers to tidy up Registry gunk like missing DLLs and unused file extensions. Click Scan For Issues, review the Registry items CCleaner has marked for deletion (we can't remember a time we spared something from CCleaner's axe), and click Fix Selected Issues.

Although CCleaner makes short work of your PC's belly fat, its cleaning capabilities are only a fraction of its total power. For the next step of your storage cleanse, click the program's Tools tile. Here, you can perform tasks such as uninstalling programs, disabling browser plug-ins, and setting restore points. Drive Wiper is an easy way to shred an entire drive's worth of data, but you'll obviously want to make sure there's nothing on a drive you won't regret firing off into oblivion.

The real jewel of the collection is CCleaner's ability to stop selected programs from launching at startup. After you've clicked the Tools Tile, click



WinDirStat can show you which files are hogging the storage, and it lets you quickly dispatch them.

Startup and disable or delete anything you suspect is a drag on your system. Unless you've filled your storage drive(s) to capacity, tweaking your startup list will probably have a greater impact on system performance than deleting data.

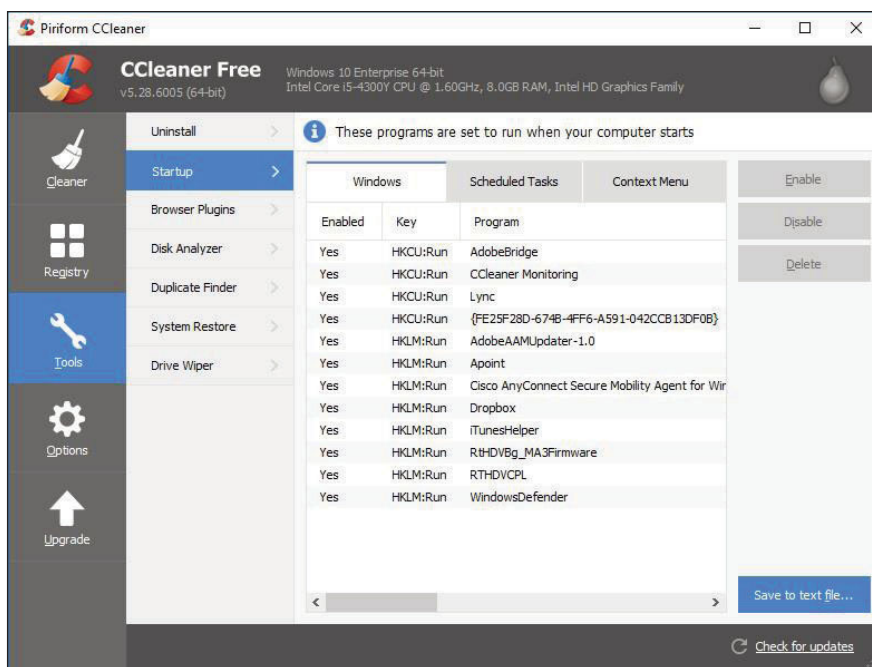
With the possible exception of CCleaner's duplicate file finder, every ability under the program's Tools umbrella is at your disposal elsewhere within

Windows. In Windows 10, for example, you can access your system's startup list from the Task Manager. However, CCleaner pulls all of the functions together and wraps them in an approachable UI, making it ideal for anyone who wants an easy and painless cleaning session. Advanced users can check out CCleaner's command-line parameters ([www.piriform.com/docs/ccleaner/advanced-usage/command-line-parameters](http://www.piriform.com/docs/ccleaner/advanced-usage/command-line-parameters)) to further extend CCleaner's functionality.

## Seek & Destroy

Just like you don't need an exhaustive tutorial on backing up your important data, we doubt you need any hand-holding to delete fat files and free up extra space. Gargantuan movie files don't exactly hide themselves, after all. However, with the help of a free and very colorful utility, you can effortlessly see exactly where on your drives the worst offenders are holed up and perhaps discover potential inefficiencies and/or redundancies.

WinDirStat ([windirstat.net](http://windirstat.net)), open-source software developed by Bernhard Seifert and Oliver Schneider, hasn't been updated in almost a decade, but it's withstood the test of time and remains our go-to program for mapping out the files on our drives. We like WinDirStat because of its unpretentious design, low



Piriform's CCleaner does a lot more than delete your browser cache.

memory footprint, and straightforward presentation of information.

After you've downloaded, installed, and launched WinDirStat, it immediately presents you with a dialog box that lists the drives in your system. Select the drive you want to scan and click OK. WinDirStat isn't the swiftest program on the planet, particularly if you put it to work on a gigantic hard drive that's filled to the brim, but the end result is worth the wait. Once WinDirStat finishes analyzing your drive, it displays all the files as a massive psychedelic grid, where files are represented as blocks sized according to how much space they take up relative to every other file on the drive.

Start your hunt in the bottom WinDirStat pane. Of course you'll want to look for the biggest blocks to make the most impact. When you click a block in the bottom pane, WinDirStat automatically navigates to and selects the associated file in the top-left pane. Right-click the selected file for a context menu of actions WinDirStat can perform. It can send a file to the Recycle Bin or delete it straightaway. Or, if you'd like to take a closer look before scouring it from your system, WinDirStat can open the file in Explorer.

WinDirStat is a great tool because it tends to find big files you might have otherwise missed. For example, we scanned an old laptop and found a pair of outdated iPhone backups that together amounted to slightly more than 12GB. After hopscotching across our grid, we were able to identify plenty of other big files collecting digital dust on our drive, and deleting them with WinDirStat was a cinch.

In some instances, WinDirStat can also locate batches of small files you want to get rid of. In its top-right pane, WinDirStat lumps the scanned drive's files together by format and then sorts them according to which files add up to the most capacity on

the drive. When you click one of the file formats, WinDirStat highlights every file with the chosen format. On our laptop, DLLs sat at the top of the stack, and we generally want to avoid those. However, if you have a particular type of file, such as JPEGs, scattered across several folders on a drive, WinDirStat shows you where they are. Clear away what you don't want.

We also suggest you use it any time you upgrade your graphics card. To grab it, point your browser to [Guru3D.com](http://Guru3D.com).

After extracting the DDU ZIP file, open the program (starting in Safe Mode is recommended) and turn it loose on your system's graphics drivers. DDU will offer you a few choices for wiping away your drivers, such as Clean And Restart or Clean

And Shutdown, plus a nice list of more advanced options (saving log files, creating a restore point, etc.). Set up DDU according to the type of cleaning you need and let it take care of any display-driver problem that simply won't go away.

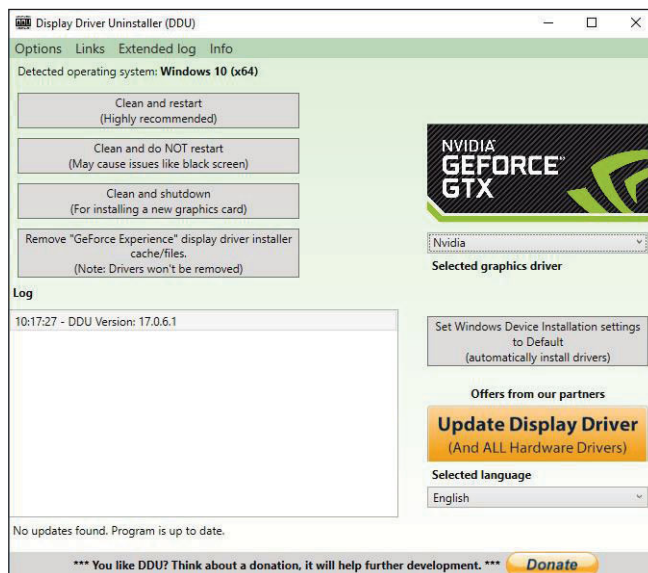
## Gone For Good

Now that your computer's drives are sparkling clean again, get in the habit of chucking your garbage on a regular basis. For typical files, you can configure Windows to skip the dialog box about tossing a file into the Recycle Bin and even bypass the Recycle Bin altogether if you're feeling particularly bold. For the former, open the Recycle Bin's

Properties dialog box and uncheck the Display Delete Confirmation Dialog checkbox. If you want to break up with the Recycle Bin for good, click the radio button next to "Don't Move Files To The Recycle Bin. Remove Files Immediately When Deleted."

You can go further. With Eraser ([eraser.heidi.ie](http://eraser.heidi.ie)), files you delete don't linger on your drive until another file needs the space. Instead, Eraser attacks them with an arsenal of data-sanitization methods (DoD 5220.22-M, Gutmann, etc.). By enabling the Windows Explorer extension during installation, you can add Eraser to Explorer's context menu, making the file shredder a right-click away.

Despite the steady decline of HDD and SSD prices over the years, storage still isn't cheap. If you want your gigs back, check out these programs and start cleaning. ■



Display Driver Uninstaller, or DDU, might solve your display driver situation.

## Drive Away Display Drivers

Every power user who has owned a graphics card will experience the occasional problem with graphics drivers, including turncoat enthusiasts who regularly switch allegiances between AMD and NVIDIA and even hardline partisans who are simply upgrading their drivers to a newer version. Put simply, we've been dealing with pesky driver issues for ages; we'll continue to deal with pesky driver issues, so why create more problems by leaving behind old driver fragments?

If you know your graphics card and its drivers are running flawlessly, we suggest leaving them alone. However, as long as you're clearing space on your PC, consider sprucing up your display-driver situation. The aptly named Display Driver Uninstaller will take care of this bit of business. DDU, as it's commonly known in enthusiast circles, is a good choice if you're looking for a clean



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www.quietpc.com

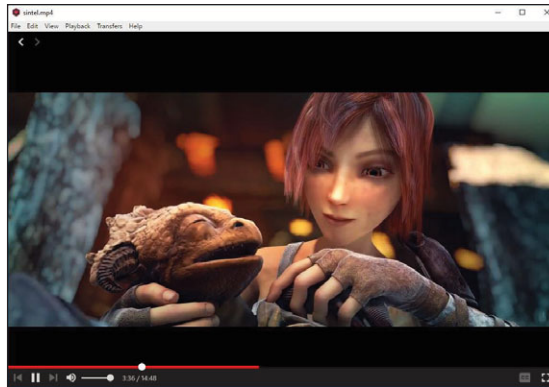
**www.booksmania.net**

## Inside The World Of Betas

### WEBTORRENT DESKTOP 0.18.0

Forgive us, but we're going to lead off this month with a bit of the ol' bait and switch. WebTorrent Desktop is definitely a slick way to stream a variety of torrents. (The project mentions videos from the Internet Archive and Librivox audiobooks as a couple of examples.) That being said, there is no shortage of software capable of playing torrented content. We're a lot more interested in WebTorrent itself and the potential it has for the future of the web.

The peer-to-peer power of BitTorrent has always felt much greater than the ability to pirate episodes of "Westworld." As the Internet continues to expand and websites load up on hi-def video, we'll need ways to more efficiently shuttle all that content through the series of tubes to our PCs. Bandwidth needs will go up, not down, and sites have to figure out how to cope. WebTorrent, for its part, could be the solution that helps everyone, whether client side or server side.



#### WebTorrent Desktop 0.18.0

##### Publisher and URL:

The WebTorrent Project;  
<https://webtorrent.io>

ETA: TBD

**Why You Should Care:** The real story is WebTorrent itself, but the desktop app is pretty sweet, too.

WebTorrent's claim to fame is that it's the first torrent client capable of streaming directly within a browser. For a better understanding of how profound that is, consider an example like Wikipedia. As the sixth most trafficked website in the world (and the top non-profit site), Wikipedia's bandwidth needs are enormous. Now, instead of panhandling you for donations, Wikipedia can use peer-to-peer

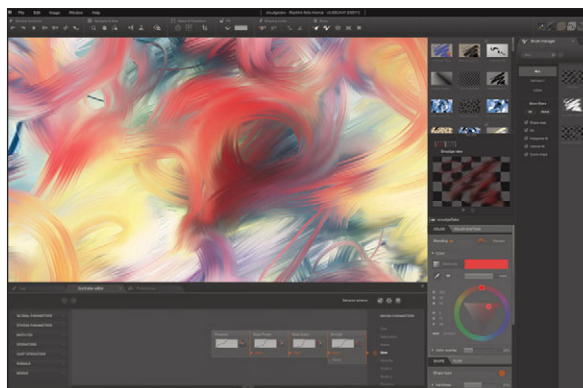
torrenting via WebTorrent for its most heavily accessed content. Sure seems like an easier solution than mailing Jimmy Wales a check for \$5, doesn't it?

Clearly, WebTorrent is bursting with promise. Go ahead and grab the desktop client to see if it meets your torrenting needs, and definitely keep an eye on the WebTorrent project. ■

### BLEANK BLACK INK 0.301.2448

Artists who have put their canvases, paints, and brushes in storage in favor of a Wacom or tablet PC have no shortage of excellent painting software to help them ply their craft. At the top of the heap are your industry heavyweights, such as Adobe Photoshop and Corel Painter, but the cost of working in these studios can be pretty pricey if you're not a professional or a student. Searching for a new hobby and want to give digital painting a shot? Consider Bleank's Black Ink.

Black Ink makes a big deal about its brushes, and rightly so. The software uses what Bleank calls "controllers" to give the artist almost total command over her digital brushes. You can set a brush's opacity to be pressure-sensitive, assign brush size based on speed, tweak scales and gradients, and more. Custom brushes also interact with the rest of Black Ink's features, opening up an "infinity of different uses," according to Bleank. Once



#### Black Ink 0.301.2448

**Publisher and URL:** Bleank;  
[www.bleank.com](http://www.bleank.com)

ETA: 2018

##### Why You Should Care:

Whether you're a digital Da Vinci or a total noob, Black Ink lets you effortlessly paint digital masterpieces.

you create a custom brush, you can share it with the Black Ink community, as well.

Under the hood, Black Ink relies on GPU acceleration to achieve a lot of its magic. By plugging into your graphics card, Black Ink is able to work with gigantic canvases. If you feel like producing a 100MP painting, Black Ink should let you do it without experiencing a slowdown in performance.

Despite Black Ink's allure, be advised that this is still beta software. Expect it to supplement, rather than replace, your existing painting software. Further, if you want to experience everything Black Ink currently has to offer, you'll have to fork over \$59.99; otherwise, you can use a feature-limited trial version. Play around with it and hope Bleank keeps marching toward a 1.0 release. ■



# Upgrades That'll Keep You Humming Along

Keeping your PC and its data safe is a never-ending job, but somebody (read: you) has to do it. You deserve a little R&R, though, so we found some software updates that cover all those bases and more. If you have an MSI Z270 motherboard, it might be time for a BIOS update.

## SOFTWARE UPDATES

### BurnAware 10.1

There are still plenty of great tools for burning CDs, DVDs, and BDs. BurnAware is one of them. Version 10.1 comes on the heels of the big 10.0 release, which treated users to a new UI. The latest update polishes that UI slightly and includes a new view for the main window, reintroducing BurnAware's classic icons. The software's Audio Grabber now gives users the option to tag their MP3s. Version 10.1 updates the software's translations, improves Win10 compatibility, and squashes minor bugs.

[www.burnaware.com](http://www.burnaware.com)

### Calibre 2.80.0

Kovid Goyal's Calibre is among the best ebook software in the business, and it's free, to boot. Goyal frequently updates the software, but version 2.80.0 still manages to deliver a nice handful of new features. The update introduces support for KFX sideloads for files created with the third-party Calibre plug-in, and there's a new Kobo driver. Aspiring (or accomplished) writers using Calibre to help package their ebooks receive a couple of additions, too. Calibre now lets you drag and drop images, stylesheets, and HTML files into the editor, and it will automatically add the corresponding tags. The software's spell checker gets a small tweak, as well.

<https://calibre-ebook.com>

### Cryptocat 3.2.08

It's never a bad idea to keep your online conversations encrypted, and Cryptocat is happy to do just that. Mostly a maintenance

update, version 3.2.08 corrects a bug that can expose your IP address. The software's Windows installer has been improved, and the Linux variant of Cryptocat now ships as an AppImage, which should increase compatibility with the myriad of Linux distros.

<https://crypto.cat>

### Nanosystems Uranium Backup 9.3.1

The multitasking Uranium Backup backs up almost anything, from virtual machines to MySQL servers. As it happens, version 9.3.1 improves Uranium Backup's MySQL functionality: The software can now back up MySQL database procedures and triggers. It will also create backups of present and future mailboxes on an Exchange Server. Nanosystems turned up the reliability knob for synchronization and cloud backups, and the update fixes a handful of bugs.

[www.uranium-backup.com](http://www.uranium-backup.com)

### PuTTY 0.68

The first PuTTY update in almost a year rolls out several changes, including a pair of vital security fixes. Previously, an integer overflow bug in PuTTY's agent forwarding code and a vulnerability in the software's Windows binaries left it vulnerable to attacks; these shouldn't be an issue now. The PuTTY team has also added 64-bit support for PuTTY's Windows tools, and OpenSSH's new private key format is also supported.

[www.putty.org](http://www.putty.org)

### XBMC Foundation Kodi 17

If you're a regular reader of *CPU's* "Bleeding Edge," then you'll know that the XBMC

Foundation was busy beta-testing its FOSS media center software late last year. This year, the build formerly known as "Krypton" is live and sporting a brand-new look—or rather, looks. Kodi's default skin, Estuary, is specifically designed as a 10-foot interface; Estouchy covers anyone using Kodi on a touchscreen device. Elsewhere, Kodi receives tweaks and improvements to many of its core features, such as a rewritten video engine and an overhauled Live TV and PVR. With the version 17.0 release, Kodi comes to the Windows Store, as well.

<https://kodi.tv>

### Xvirus Anti-Malware 7.0.1.0

The latest big release further bolsters Anti-Malware's defenses, equipping it with three new features. Two of the additions focus on safeguarding your network, while the third focuses on stopping ransomware before it holds your data hostage. Version 7.0.1.0 boasts improvements almost from top to bottom, too, with a new multithreaded scanning engine, a new online dashboard, faster scans, increased stability, and more.

[xvirus.net](http://xvirus.net)

## DRIVER BAY

### MSI Z270 XPOWER GAMING TITANIUM BIOS 1.1

MSI has actually released updated BIOSes for several of its Union Point motherboards, so check the website even if you own a different MSI Z270 board. The new BIOS improves compatibility with Intel SSD 750 solid-state drives, as well as unspecified M.2 drives and system memory.

[us.msi.com](http://us.msi.com)

## CPU

Game Of The Month

Yeah, we know you have blogs to post, video to encode, reports to write, and code to compile. We do, too, but you have to take a break once in a while (and maybe blow some stuff up). That's why each month we give you the lowdown on what to expect from the latest interesting games.



As BioWare's most beloved tent-pole franchise, Mass Effect has always been about maximizing player choice. These games are all third-person RPG space operas, but practically everything else, from the looks and gender of your player character to the romantic encounters, dialog choices, and responses to a multitude of ethical quandaries, are yours to decide.

Aside from the universe and a handful of returning alien races, the new game has little in common with the trilogy. To recap, humans are newcomers to the exclusive club of space-faring bipeds, but thanks to the discovery of Prothean technology on Mars, our species develops faster-than-light space travel. Two years after Commander Shepard takes the helm of the Normandy in the original game, the Andromeda Initiative completes the construction of a series of massive Arks designed to transport 100,000 Turian, Asari, Salarian, Quarian, and human cryopods on a 25-million-light-year journey to the Andromeda Galaxy. More than 600 years later, humanity's Hyperion Ark is the only one that arrives, and it's late. To make matters worse, the "Golden Worlds" planets have become uninhabitable thanks to a deadly energy matrix referred to as The Scourge and an ongoing threat from the blood-thirsty Kett.

I chose Sara Ryder as my player character, the daughter of Alec Ryder, the Pathfinder tasked with exploring worlds, scouting for colonial outpost locations, and making first contact with aliens. As events unfolded, I was immediately reminded of the previous games. The synth-heavy soundtrack is back, and it's fantastic. The Paragon/Renegade dialog response system is gone in favor of a more organic set of responses, but

## Ryder In The Sky

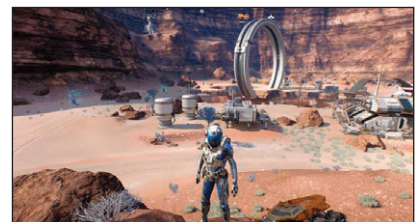
BY ANDREW LEIBMAN

\$59.99 (PC, XOne, PS4) • ESRB: (M)ature  
BioWare • [www.masseffect.com](http://www.masseffect.com)

often you're left having to choose between the cliché or silly response. The writing, both from a dialog and characterization perspective, seems to have dropped off considerably compared to the previous games.

As before, you're constantly being pelted with missions. One of my biggest gripes with ME:A, however, is that you can only have one task active at a time, and rarely do markers appear to indicate the presence of nearby inactive mission objectives. Exploring a planet without an objective marker to lead you in the right direction can disrupt the linear narrative. I managed to exchange mission details with an NPC on Eos but never got an updated mission marker because I wasn't supposed to access that part of the map yet. Another disruption came when I encountered a massive flying mechanical tripod called an Architect on the ice planet Voeld. There was no explanation, just my squad mates essentially saying, "look, another one!" Back on Eos, the first planet you unlock, I met another Architect, but this time I got the cinematic intro and the accompanying explanation. Other gripes include too many recycled character animations, an inability to command squad mates in battle, a cast of mostly one-dimensional characters, and bland side missions. So much of what doesn't work well comes down to polish. This game feels like it was rushed out the door.

ME:A has potential. The Andromeda Initiative's colonial ambitions are a perfect lens to view humanity's strengths and weaknesses. The combat mechanics are light years better, the Nomad is incredibly fun to drive, and the Tempest is every bit as cool as the Normandy. Despite my many qualms, the previous games kept me coming back because of unequalled dialog and stellar characters. ME:A resolves many of my quibbles with the franchise, but it falters when it comes to compelling dialog and characters. Maybe if the internet complains enough, Bioware will patch those in. ■





## TOM CLANCY'S GHOST RECON WILDLANDS

Tom Clancy's Ghost Recon: Wildlands puts you in the role of a disavowed U.S. commando taking on a Mexican drug cartel that has chosen Bolivia—yes, the entire country—as its new base of operations. The game feels a lot like a hybrid of two of Ubisoft's other properties, Far Cry and Tom Clancy's The Division. Like Far Cry, the game turns you loose in a massive world with a nice variety of environments and hosts of NPCs, including Bolivian civilians, local military forces, and of course members of the Santa Blanca cartel. Like The Division, Wildlands is a third-person shooter, albeit with a first-person aiming mode you can use when needed, and there's a lot of emphasis on playing as a member of a squad.

Wildlands borrows some of the best aspects of both games, and Ubisoft has done an incredible job of building an in-game Bolivia. The game's world is fully explorable, and it's so scenic and well-made that you will want to explore; this is a big plus.

It's also nice that the game provides lots of kinds of missions and activities for your commandos to undertake; you'll engage in seek-and-destroy missions, gather intel, rescue hostages, steal stuff from the cartel to hand over to the local resistance, and more, and you'll get around in a myriad of vehicles, including everything from dirt bikes to massive helicopters, and they are nearly all fun to drive or fly. Wildlands lets you fast-travel to bases and other points of interest in order to get around the huge map quickly, but I often found myself grabbing a chopper or SUV and getting around the old-fashioned way, just for the fun of it.

Ubisoft also provides three AI teammates that you can play through the entire game with if it suits you, although they aren't perfect (more on this in a sec). If you would rather play with friends, you can do so, and as with The Division, your friends can join and drop out of your squad seamlessly at any point; you can also jump into an online co-op game



## Strikes & Gutters

BY CHRIS TRUMBLE

\$59.99 (PC, XOne, PS4) • ESRB: (M)ature  
Ubisoft • ghost-recon.ubisoft.com

with randos if you want, but in these instances you don't get voice chat, which (as you can imagine) is kind of a problem when you're trying to coordinate a covert strike on a Bolivian army base.

The game presents two other pretty big problems: First, what initially seems like a vast world of interesting possibilities quickly boils down to an increasingly repetitive set of the same kinds of activities. The variety in terrain and situations helps ameliorate this a bit, but by the 10th or 12th time you hijack a supply convoy, it starts to get a little stale. Second, your AI squad mates are helpful and can have a meaningful impact in combat, but they also have a tendency to get lost from time to time, they have a hard time following orders, and they chatter incessantly between missions. Their chatter is also incredibly repetitive and becomes actively aggravating when they try to talk over the few snippets of mission briefings and other important audio the game offers.

Other weird squad issues include the fact that you can jump in an SUV or helicopter and take off immediately, leaving your mates behind, but within a few seconds they'll appear in your vehicle anyway, as if by magic.

Luckily, Wildlands' combat is pretty good, which helps overcome some of the game's annoyances. Also, the ability to mark enemy targets with your drone, binoculars, or rifle scope and have your AI team take them out at your signal somewhat counters the things they do that detract from the fun.

On balance, Tom Clancy's Ghost Recon: Wildlands is fun to play, and the ability to have your friends jump in and out of your game as need be is a plus. If third-person Far Cry with your pals (or The Division without stat min-maxing and bullet-sponge bosses) sounds fun to you, it's probably worth giving this game a shot. ■





## A Sharp-Tongued Sneakquel

BY VINCE COGLEY

\$39.99 (PC); \$49.99 (XOne, PS4) • ESRB: (M)ature  
Focus Home Interactive • [www.styx-game.com](http://www.styx-game.com)

Stealth fans have enjoyed a bountiful year of games that require you to slink through levels and quietly dispatch your enemies. A little over a year ago, Square Enix gave us its episodic reboot of the HITMAN franchise. Last month, we played (and enjoyed) the fourth installment of Rebellion's World War II era sneak-and-snipe game Sniper Elite 4. We haven't had a chance to play Shadow Tactics: Blades of the Shogun, but by most accounts the samurai stealthier is a can't-miss experience. And of course, Dishonored 2 claimed *CPU's* Game of the Year crown.

This month, Focus Home Interactive released *Styx: Shards of Darkness*, the follow-up to 2014's *Styx: Master of Shadows*. *Shards* is actually the third game in French developer Cyanide Studios' Of Orcs and Men universe, but Cyanide has ditched the action RPG elements of the first game to focus solely on the titular goblin and his more subtle approach to killing.

Before we dive into the game itself, we have to discuss our larger-than-life-yet-smaller-than-a-seven-year-old antihero. Styx is surly and sassy and has an ogre-sized chip on his shoulder, but if you know anything about his origin story from *Master of Shadows*, you'll cut him some slack. Less appealing, however, is how Cyanide writes its irascible and irreverent goblin. Styx's frequent fourth wall breaks are somewhat jarring, not really because the trope is relatively rare in the fantasy genre but rather because the rest of Styx's world plays it so straight. When everyone else in the game sticks to the script while Styx is riffing on pizza (yes, really) and the Terminator (also really), it really spoils the ambience, like wearing a Christmas sweater to a funeral.

We'll level with you: We could've pardoned *Shards of Darkness* for its out-of-place joke delivery if the jokes themselves had been genuinely amusing. We're not ashamed to enjoy low-brow humor every now and then, but really good ribaldry requires an artist's touch. Instead of taking the time to get the bawdy humor right, Cyanide goes straight for the bottom shelf, whipping out one-liners you can hear from every eighth-grader who thinks he's the next Daniel Tosh. This isn't the first *Shards* review to make the following observation, but it's almost as if Cyanide thought making Deadpool a goblin and putting him in "*Lord of the Rings*" would be a slam dunk by default. In reality, the end result is a brick.

The reason why we've spilled so much ink on Styx and his cringe-inducing "comedy" is that *Shards of Darkness* is an otherwise decent game. Many stealth games, *Dishonored* included, have tipped toward "action stealth," giving their protagonists godlike powers to lay waste to their foes if discovered. On the whole, *Shards of Darkness* stays faithful to a true stealth experience. Discovery regularly leads to death, even at the game's lower difficulty settings. You do have a tech tree to upgrade Styx's tricks, but they're not geared toward making the goblin an unstoppable killing machine in open combat.

We also liked several of *Shards of Darkness*' mechanics. Styx is able to clone himself, and the clone can then do things like create distractions and lure guards away from their posts while Styx sneaks in unscathed. Upgraded, it's probably the coolest and most original ability in the game. Another nifty skill is Amber Vision, which displays guards' line of sight and also highlights collectible items and other objects Styx can interact with. We appreciate Cyanide's commitment to making Styx more powerful by making him harder to find rather than harder to stop.

*Shards of Darkness*' levels are decent enough, even if the camera and platforming elements aren't as sharp as they could be. Its story works insofar as it keeps you moving through the game without being a drag, which brings us back to *Shards of Darkness*' central problem: the main character. Styx wears his irredeemably awful behavior as a badge of honor, but we saw it as a scarlet letter. For as hard as Styx works to sabotage his enemies, the only thing he really manages to sabotage is his own game. ■





## Q&A With Joshua Pearce

# 3D Printers In The Average American Household

Joshua Pearce, an associate professor at Michigan Technological University, has for years conducted research into open sustainability technologies, or the “application of science and innovation to ensure a better quality of life for all.” Among other things, this has involved exploring the economic and environmental benefits of using open-source 3D printers. Pearce’s lab has long known it can considerably reduce the costs of obtaining high-end scientific equipment by 3D printing its own, but Pearce wanted to explore if average American consumers—even those lacking 3D-printing experience—could see similar benefits by 3D printing common household items such as smartphone cases, shower heads, and camera lens covers in the home.

For a recent study, Pearce directed an undergraduate student with no 3D-printing experience to configure a LulzBot Mini printer and locate and download free 3D print files for 26 common household items that she then printed. Pearce ran an economic analysis that took into account the cost to buy the 3D printer and operate it over a year’s time under the assumption a household would print one item on average per week. He compared this to low- and high-cost estimates for store-bought equivalents for each item. Against the low-cost estimates, Pearce found 3D printing resulted in 93% savings for consumers. Against high-cost estimates, savings reached 98.65%. Pearce also found that with the low-cost estimates, the 3D printer would pay for itself and all related printing costs in three years. Consumers, however, would see a 100% return on their 3D-printing investment after five years. With the high-cost estimates, the printer pays for itself after just six months and generates \$12,000-plus in savings after five years. We spoke with Pearce about the study, the potential of 3D printers, and more.

(You can read our full conversation at [www.computerpoweruser.com/24252](http://www.computerpoweruser.com/24252) )

**Q :** Essentially, the results of your recent study suggest average American consumers can not only save considerable money using a 3D printer in the home but also see a substantial return on their investment. What motivated this study, and was it actually a continuation of research you started in 2013 on this topic?

**JP :** In fact, it probably even goes a little further back than that. It goes all the way back to when I really started to become interested in 3D printing. We were doing prototypes for solar-powered laptops for the developing world. I was finally a professor, and I finally had access to an actual Rapid prototyper. I was so excited. The students had done these really cool designs, and then we went to go get them prototyped. The prototypes just made of simple plastic cost more than the whole solar system and almost as much as the computer. It was kind of like, “This is never going to work in the developing world if it’s



going to cost us this much to do” because we weren’t mass manufacturing. The whole idea was for people to kind of make it themselves. So we started looking around for some way to do prototyping without draining the bank account.

I came across the RepRap project. RepRap stands for self-replicating rapid prototypers. It’s 3D printers that print themselves. It just so happens that around that time, FDM—

the kind of patented fused deposition modeling where you’re taking filament and laying down layers to build up a 3D-printed object—had its patents expire. So the RepRap Project, instead of continuing on with another patent, realized it was kind of stupid because anyone who bought one of its printers could immediately start to make a second one on their own. There was no real way to stop that, so RepRap open-sourced it.

A University of Bath professor and team spread it all throughout the world trying to create these 3D printers that could make themselves and open-sourced it. When I saw that I salivated. It was very clear this was going to be huge. So we started in on it very hard in our group. We started doing prototyping like everyone else at the time, but then we quickly realized that we could use it to do manufacturing of our own scientific tools, which we could then open-source and have this kind of distributed manufacturing paradigm for sharing scientific tools.

We were doing that for a while, and if you know anything about scientific tools, you know they are highly overpriced. There's a small market for them. They aren't generally mass produced. So you're buying thousands of dollars of items that do very, very simple things. We found that we could 3D print most things we needed in our lab to do solar research and save thousands and tens of thousands of dollars for each item we were printing. The economic justification for doing 3D printing was crystal clear to us. Literally right now, I'm printing something in my office on a \$2,000 printer, and the object that I'm printing is \$1,000. By the end of the day, I'll have paid for half of the printer just for one thing I need. We wanted to sort of continue that thought and look at normal consumers.

Back in 2013, we said, "What if the normal, everyday consumer looked at the free plans for RepRap on the internet, downloaded them, and built her own printer? Would that justify itself economically for printing out normal things a consumer would need and not scientific tools or medical tools?" Those printers cost \$500, and the results we saw were very encouraging. It was fairly easy for the normal American consumer to pay for the printer, to economically justify it again using that same kind of assumption that you wouldn't be printing constantly, but maybe one time a week to make it worthwhile.

That study was relatively well-received. I think it started to open up a lot of people's eyes that maybe all the hype about 3D printing actually had some foundation to it, that economics might push this in the future. But I would say one of the really strong criticisms of the study was that we were assuming the American public was technologically savvy enough to build its own printer. I've run a class for years where I have engineering students do that, but they are engineering students, and they're highly motivated and they're self-selected as people who are interested in additive manufacturing, so that was a fair critique. With this new study, I put that critique to the test. I took a second-year undergraduate student who had never taken my 3D printing class. She'd seen some 3D printers,

like the large-scale multimillion dollar ones working at NASA, but she had never used one. She didn't know anything. I handed her the printer with no instructions and said, "I want you to print out 26 things you think a normal person might want. Go." And this is what we came up with.

**Q: Can you talk about the savings and ROI figures you arrived at with the study?**

**JP:** The way we did it was we monitored the electricity used for the 3D printer and the plastic used. As of right now, the plastic is by far the dominant expense for operating a 3D printer. But everything we printed for this study was done on less than \$20 worth of plastic, so even though it's the dominant expense, it's still not that expensive. The reason we included the electricity is that in the future, it's my very strong estimate that the price of filament is going to continue to decrease. For example, we did everything in PLA [polylactic acid]. The average cost of PLA filament, sort of what people are buying on Amazon, is around \$24 per kilogram. I know you can buy small batches of PLA pellets for \$5 a kilogram, and if you buy large batches, it goes down to around \$1 a kilogram. So there's a lot of space left to squeeze the profit margins out of filament manufacturers. That eventually will happen more and more as 3D printing scales.

When it does happen, then the cost of electricity actually starts to matter a little bit. Right now, it's on the order of tens of cents depending on where you live vs. dollars for the filament. We calculated the cost of the printer to buy it and the cost to operate the printer over an entire year, assuming you'd print one thing on average per week, and we used the size of the things we selected for those 26 items to be representative. So, we took the average size, the average printing time, the average filament, and the average electricity used, and that got us a cost to operate the printer for a year. Because these 3D printers are RepRap-style printers, the company that makes the one that we used literally uses its own

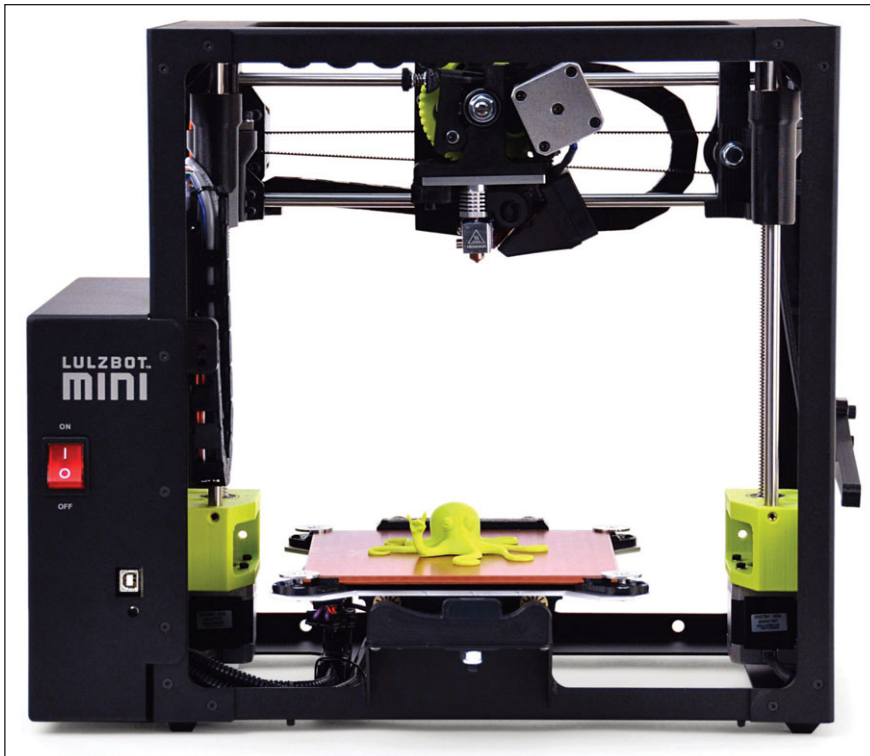
printers to print out many of its parts. The most likely parts to fail are also 3D printable, so you could print upgrades or replacement parts. Keeping these things alive for five years is a very conservative, reasonable assumption.

To calculate the return on investment, we looked at that cost that you'd put in for electricity and plastic and purchased the printer as an investment the same way as if you would buy stock on the stock market. Then we counted up all the savings you get over that year. So for each product that was printed, we had a high and low estimate. The low estimate was the cheapest equivalent we could find on the web or close to it. The high estimate was one that was a little bit more close to the actual object. So if it was a specific type of, say, lens cover for a specific camera, it had to be this. It just wasn't good enough to get a generic one. You had to get the exact measurements right. So, for things like that, that's where you got very high numbers. From a return on investment for the kind of low-end side, you're on the orders of hundreds, and if you go to the high-end side, you're looking at almost a 1,000% return on your investment.

**Q: Were the ROI numbers you calculated after the study in line with your expectations prior to starting the study?**

**JP:** They were sort of within reason. They are nowhere near as high as if you printed medical or scientific equipment, and it's still fairly conservative because printing one thing a week really isn't that much. If you really think about it, if you have kids and you go to birthday parties, you could basically pay for the 3D printer just on offset toy purchases. It really depends on how much you use it and what your normal consumer-purchasing habits are. That's why we got a very eclectic collection of 3D-printed objects, because we were trying to get to a place where hopefully every person would see at least one thing on the list that they might want or normally purchase.





In a recent experiment, Joshua Pearce, an associate professor at Michigan Technological University, asked an undergraduate student with no 3D-printing experience to configure a LulzBot Mini printer such as the one shown here and then locate, download, and print the free 3D print files for 26 common household items.

The thing that surprised me was the next calculation. Most of the websites that have free repositories of 3D-printable designs also keep track of how many times a design is downloaded. The reason they do that is to encourage designers to share their things. It's kind of like an ego boost to see something you've made downloaded a hundred or thousands of times and that people are using it all over the world. It's kind of fun for people and a way to kind of share back with people who have shared things with you in the past.

We have the download statistics of the 26 items that we looked at. We knew approximately how much a 3D operator would save by printing one of these objects, and we assumed they just downloaded it and printed it once, and this again is a fairly conservative assumption. It's sort of like an MP3 you can download from the web. You can assume everyone who downloaded an MP3 probably listened to it at least once but

probably a lot more than that. If you're looking at something like the Barrel of Monkeys game where you have a bunch of little monkeys, users probably printed more than one monkey, but we assumed everyone printed one of each thing.

Just making that assumption with just those 26 items, we know the 3D-printing community in the world has saved about \$4 million just on those 26 items already. The exact number isn't important, but the idea is that people are beginning to use 3D printers not just for prototyping but for actually making consumer products for themselves. And that's really surprising and shocking—that we've already started to move toward a distributed manufacturing paradigm, which I don't think anyone thought was coming this fast.

**Q : Can you talk about the RecycleBot and the value it brings to 3D printing, including in terms of reducing waste, cutting costs, and more?**

**JP :** The RecycleBot is a waste-plastic extruder. Again, going back several years because we were focusing on the developing world and we were chewing through plastic like crazy in our lab and it was kind of expensive, we asked if there was a less-expensive way to get 3D-printable plastic. We started off by just recycling our own prints. You could grind them up and put them in this device that would extrude filament, and then you could print with it and that was pretty easy. Then we started looking at other things. The first one we tried was HDPE [high-density polyethylene], which is the plastic of milk jugs and containers for dishwasher soap and detergent and things like that. And it worked. We were able to make filament for less than 10 cents per kilogram, where that cost of filament was basically the cost of electricity to run the RecycleBot. It was pretty exciting, and we did some interesting stuff with it here, and it started to spread.

Now, I'd say there's something like a dozen manufacturers of something like the RecycleBot. They might be just selling it to extrude virgin pellets into filament, but you could just as easily take bad prints, old plastic food containers or whatever, clean them off, dry them up, shred them up, and stick them in. When we first started, we were using an office shredder to literally shred waste plastic from my lab group and turn it back into filament. At this point now, there have been dozens of open-source hacks on different types of RecycleBots. There are automated spoolers. There are all kinds of wonderful things happening. The RecycleBot technology is a little behind where the 3D-printing technology is right now, but in a couple of years, it will be ready for showtime, and you will have the option of if you finish your orange juice in the morning, you rinse out the bottle, dry it, throw it through a small shredder, and turn it back into filament. Then you can make whatever products you happen to want. That's when no one can compete with those costs. You can't even get recycled filament for the cost you could make it for yourself in your own house. ■

# Look For *CPU* At These LAN Parties

**04.01-02.17**

Michigan Gamers for Giving 2017  
Ypsilanti, MI  
[www.gamersoutreach.org](http://www.gamersoutreach.org)

**04.07-09.17**

SpokLAN: GULP 17.04 - Nerd Side Story  
Spokane, WA  
[spoklan.net](http://spoklan.net)

**04.07-09.17**

VectorLAN 8  
Portland, OR  
[www.lanreg.org/pdxlan/vectorlan8](http://www.lanreg.org/pdxlan/vectorlan8)

**04.08-09.17**

BoilerFrag 10.0  
West Lafayette, IN  
[pugg.org](http://pugg.org)

**04.08-09.17**

River Valley LAN  
Russellville, AR  
[www.elayin.com](http://www.elayin.com)

**04.15.17**

KCGameOn 74  
Kansas City, MO  
[kcgameon.com](http://kcgameon.com)

**04.15.17**

Oklahoma Gamers Group  
Oklahoma City, OK  
[www.okgg.org](http://www.okgg.org)

**04.15.17**

Source Gaming Lounge  
Denton, TX  
[www.sourcegaming.org](http://www.sourcegaming.org)

**04.22-23.17**

Ultimate Gamer Showdown 3  
Dauphin, MB  
[www.aybonline.com](http://www.aybonline.com)

**04.28-30.17**

DREAMHACK Austin 2017  
Austin, TX  
[austin.dreamhack.com/17](http://austin.dreamhack.com/17)

**04.28-30.17**

Forge LAN 10  
Medina, OH  
[www.forgelan.com](http://www.forgelan.com)

**04.29.17**

EagleLAN 2017 FGCU  
Fort Myers, FL  
[eaglelan.com](http://eaglelan.com)

**04.29.17**

eDrenaline eSports  
Ashland, OH  
[www.facebook.com/groups/UGGeSports](http://www.facebook.com/groups/UGGeSports)

**05.13-14.17**

\$2000 CS:GO Event Powered by Novastar Gaming  
Kansas City, MO  
[www.novastargaming.com](http://www.novastargaming.com)

**05.19-21.17**

BaseLAN 31  
Winnipeg, MB  
[www.aybonline.com](http://www.aybonline.com)

**05.20.17**

Oklahoma Gamers Group  
Oklahoma City, OK  
[www.okgg.org](http://www.okgg.org)

# cpu®



# Across The Nation—& Beyond!

\* Event scheduled to include a *CPU* case mod contest

**05.20.17**

Source Gaming Lounge  
Denton, TX  
[www.sourcegaming.org](http://www.sourcegaming.org)

**05.26-28.17**

PAX West\*  
Seattle, WA  
[www.paxsite.com](http://www.paxsite.com)

**05.27.17**

eDrenaline eSports  
Ashland, OH  
[www.facebook.com/groups/UGGeSports](http://www.facebook.com/groups/UGGeSports)

**06.10.17**

Eighty8Gaming Lanstravaganza 2  
Spring, TX  
[www.eventbrite.com/e/eighty8gaming-lanstravaganza-2minecraft-day-tickets-31693934411](http://www.eventbrite.com/e/eighty8gaming-lanstravaganza-2minecraft-day-tickets-31693934411)

**06.10-11.17**

KCGameOn 75  
Kansas City, MO  
[kcgameon.com](http://kcgameon.com)

**06.17.17**

Oklahoma Gamers Group  
Oklahoma City, OK  
[www.okgg.org](http://www.okgg.org)

**06.17.17**

Source Gaming Lounge  
Denton, TX  
[www.sourcegaming.org](http://www.sourcegaming.org)

**06.24.17**

eDrenaline eSports  
Ashland, OH  
[www.facebook.com/groups/UGGeSports](http://www.facebook.com/groups/UGGeSports)

**06.25.17**

FortLAN XI  
Fort Wayne, IN  
[www.facebook.com/fortlan.org](http://www.facebook.com/fortlan.org)

**07.15.17**

Oklahoma Gamers Group  
Oklahoma City, OK  
[www.okgg.org](http://www.okgg.org)

**07.15-16.17**

River Valley LAN  
Russellville, AR  
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## Q&A With Ryan “OpTic J” Musselman

### OpTic Gaming Co-Founder

### On How It All Started

**Q:** When did you start OpTic Gaming, and how did you decide to start an eSports team?

**RM:** OpTic was born in 2006, and the original intent was to compete online, primarily as a pick-up team who played together after work and school. The eSports scene for Call of Duty, our first eSport, was in its infancy. You would only find tournaments online, and it was mainly for bragging rights. In 2009, H3CZ [Hector “H3CZ” Rodriguez] and his brother started creating content, leading to a strong fan base and ultimately creating a desire to expand into eSports given that CoD was on the rise. 2010 became the year our professional CoD team first competed at a LAN, although in 2007 H3CZ and I competed at a small event in Florida (we placed third).

**Q:** What was the first thing you did to get the team rolling and make it official?

**RM:** Overall, it was truly paying attention to the eSports space: how it was developing, who the notable players were, how the up-and-comers were breaking into the scene, and so on. This is a mission and practice that will be core for generations to come, just as it is in traditional sports today.

**Q:** Can you talk about the process of recruiting players? How did you go about finding people to recruit to the team, and what kind of tryouts/auditions/interviews did you have?

**RM:** Gamebattles.com was a strong source for player recruitment. It essentially was our virtual database for tracking teams and players and getting to know who was on the rise.



**Q:** Who was your first team sponsor, and how did you get that lined up?

**RM:** Our first team sponsor was a competitive gaming website that is no longer in existence, known as NxGamers.com. They saw the early traction Gamebattles.com was achieving and ultimately wanted to compete. It's unfortunate it didn't work out, but we truly enjoyed our time with them. The sponsorship came about through the development of online relationships in forums and Xbox Live. In fact, we can attribute a lot of our OpTic friendships to Xbox Live and various online forums. If NxGamers.com was not our sponsor, we would not have met H3CZ . . . he was a referee on the site and quickly became a friend of OpTic because he was always available to help.

**Q:** Does OpTic have a home base where team members live and practice?

**RM:** We have two large houses for professional players and content producers to practice, live-stream, create

content, and curate relationships. Scuf Gaming was very supportive, like always, in helping us acquire our current CoD house, and as you can see from the many videos, it's served as the main stage for our media efforts.

**Q:** OpTic Gaming of course has several teams based on various games the organization competes in. When do you know that a new game warrants consideration for its own team?

**RM:** There's no ultimate formula so far, but the big indicators for us to consider expanding usually start with active community support: Is there an audience? Do they love it? Is there a steady and consistent rate of adoption? Next up is development: Is it built for competition? Does the developing company understand eSports? Is there an established infrastructure to continue to enhance the game for eSports? We also have to consider developer support: Is there an official league or commitment to work with an organization that runs leagues? Are tournament earnings large enough to attract top talent and justify the time and resources needed to becoming a professional? These things are just a starting point. It's very difficult for new games to spawn into fully supported and well-rounded eSports.

**Q:** At this point, eSports is clearly more than a fad. When you started OpTic, did you foresee eSports getting as big as it has?

**RM:** When we started OpTic, it was more about friends getting together after school and work to improve our craft and play for the love of



the game, as well as the competition. To this day, that core foundation still rings true, and I see it played out in all aspects

of our organization, from competition to content creation. That said, I don't think we really knew the full potential

of eSports, yet remained positive, hopeful, and active in helping it grow. Core to the development of OpTic is our commitment to support exponential eSports growth.

## OpTic Sponsor DXRacer: What We Look For In An eSports Team

Ever wonder how gaming gear companies choose the teams they sponsor? We did, too, so DXRacer's Dan Leshock told us.

**Q:** How many gaming teams/organizations does DXRacer have formal relationships with?

**DL:** Our eSport presence is quite impressive, with over 30 organizations under our banner! We pride ourselves on partnering with the best teams in eSports.

**Q:** What kinds of things does your company do for eSports teams as part of its sponsorship agreements?

**DL:** Aside from supporting the team financially, DXRacer has a wide array of benefits for being under our banner, such as streaming opportunities on the DXRacer Twitch page, invitations to attend events with DXRacer, and quarterly activations on social media. However, one of the coolest perks that we provide to teams is the creation of their own custom chair. These are used to outfit their homes and streams, as well as an additional merchandise item for the community. It is a cool way to solidify and push the partnership.

**Q:** Do teams come to you and ask for sponsorship, or do you scout out teams to offer sponsorships to?

**DL:** It really is a mixture of the two. Many teams reach out directly, but we also scout around and keep tabs on specific teams. Part of my position at DXRacer involves analyzing upcoming games and where the company will want to have a presence. From there, we find teams that can fit that role and more.

**Q:** What criteria do you use when deciding whether to sponsor a gaming team, and how much weight does each factor carry?

**DL:** While team inquiries are handled on a case-by-case basis, we like to focus on three major factors for any evaluation: community size and growth, the games they play and their North American/global ranking for them, and their ability to push the partnership for both themselves and DXRacer. Each of these pieces creates the groundwork for team evaluation and holds equal weight on how we assess an inquiry.

**Q:** What's the best advice you have to offer teams that are out there right now looking for sponsors?

**DL:** Unique offerings are key. As sponsorships develop out in the space, they require more time and dedication from the team to make it stand out against the crowd. Be open to unique activations that are not typical of other teams. Continually innovate your processes and bring ideas on how to push the sponsor's brand further, while bringing overall benefits to your organization. And finally, always have a nice presentation ready for anyone you talk to!



**Q:** What's the over/under on years until eSports events outsell traditional sporting events?

**RM:** I don't have a specific number, but to speak in terms of numbers, we're already seeing the beginnings of this trend. There have been multiple articles over the past few years that show how League of Legends and Dota 2 have surpassed viewership over the World Series, BCS, and the NBA finals. It's not only impressive, but a true testament to the growing power of the supporting mediums like YouTube, Twitch, and more.

**Q:** What's your proudest moment as a co-founder of OpTic Gaming?

**RM:** It's a combination of two milestones. First, seeing the success of my friend Hector as he took something so raw in its early days and turned it into an organization with an incredible following. Hector and I met through competition on Xbox Live 11 years ago, and it was an honor to have him as one of my groomsmen when I got married in 2015. It's a testament to the unique relationships people are building in eSports. He is someone I have come to respect and has a hilarious personality that is so perfect for the gaming scene. Coupled with that, officially coming onboard in a full-time capacity to team with Hector on developing OpTic for future success and opportunity. I'm sorry, I can't just do one moment—there are three—but I feel they all sync. In 2010 at MLG Dallas, the term "Green Wall" was coined in response to a host of fans and OpTic members all wearing green, standing behind our players yelling loudly as they competed. That was my first MLG event, and to this day, it remains my favorite. ■



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